THE PRACTICE OF FORESTRY

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SECTION I.

PLANTING

THE

PRACTICE OF FORESTRY.

CHAPTER I.

INTRODUCTION.

THERE is much truth in the proverb, "Well begun is half done." It need not here be questioned whether this is literally true or not; but one thing is certain, in the planting and culture of forest-trees every false step taken must be a backward one.

As soon as a piece of ground is fixed upon for planting, the forester should take every available means and opportunity of knowing all that can be known about it. By this it is not implied that any one is capable of knowing everything that is desirable to be known, but that he should put himself in possession of as much knowledge of the subject as he possibly can. We often learn as much from the mistakes and failures as we do from the successes of ourselves or others.

Experience counts for much in any pursuit, but to

be fully successful in planting we need a local as well as a general experience. A forester entering upon a new situation, for example, will be all the wiser for waiting a complete round of the seasons before doing much either in planting or thinning. The climate requires close observation; the soil must be well studied; and the natural enemies, whether quadrupeds or insects, which are liable to attack the trees, have to be carefully considered and dealt with. To learn and understand the power and influences of all that surrounds us in nature, is more difficult by far than to read books or listen to human instructions.

The objects of planting are usually manifold—such as affording shelter to crops and farm stock, providing covert for game and foxes, embellishing and beautifying the landscape, ameliorating the climate, and, most practical of all, supplying the district with wood and timber, and remunerating the proprietor for the outlay of his capital. It is seldom, perhaps, that any single plantation is expected or intended to fulfil all these requirements; but as this is not an impossible combination, it must be evident that, in order to plant with any degree of certainty, much forethought and consideration are required, and also no small experience.

The form and outline of a plantation are matter for wise consideration; and not only the boundary-line and appearance when young, it must also be looked at through the vista of coming years, and in its state of maturity and old age. It should likewise be viewed prospectively in connection with other plantations and all other surroundings—such as hills, valleys, rocks, lakes, rivers, roads, and fields—and should bear a due proportion to the general features and objects of the

surrounding landscape. Large areas of plantation in the midst of small arable fields do not look well; neither, on the other hand, do small patches and narrow belts look elegant amongst broad and expansive fields. The north and east sides of fields, steadings, cottages, gardens, &c., should, in this country at least, be sheltered and well protected by trees; while, on the other hand, the south and west should be left open to the sun. Nothing of a rural kind is less in harmony with good taste, than a steading or cottage with trees in close proximity to the house on the south and west sides, while the north and east are bare and exposed.

The breadth of the various plantations is also a subject of no small importance, and deserves much thought and consideration. No fixed rule can be laid down as applicable to all cases; but if an error *is* committed, let it be that of planting too broad rather than too narrow. Indeed, unless the ground is too valuable to plant, or the fields too small, no shelter-belt should be of less breadth than 3 chains. This ought to be regarded as the minimum breadth where useful timber is the object in growing it. There are doubtless useful belts not more than 2 chains wide, but the trees in such are necessarily either bushy and of stunted growth, or weak, tall, and slender, comparatively speaking.

Where the planting is primarily designed to please and gratify the taste, and where the plantation is viewed from various points, it is wise and judicious to set up as many artificial trees as fairly to represent the future plantation, or single tree, as the case may be.

Taste in regard to plantations varies, as it does in

other things. Bygone generations planted chiefly in rows and straight lines, and now nothing will please but bends, curves, and irregularities. We know of no standard or rule for the one system more than the other; and, indeed, if our ancestors erred in the direction of straight lines, we possibly also transgress in regard to curves. It is, indeed, a legitimate question to ask, Why are we so fastidious as to the curves and circles in plantation fences, when we do not object to straight lines of railroads, rows of telegraph poles, roads, furrows, ridges, field-fences, streets, rows of houses, ribbon-borders, gardens, walks, and an infinity of other things? Practically it would be well to at least modify our passion for curvilinear outlines of plantations, especially seeing that the fences that now protect them are usually of wire, or such other as can only be practically and economically erected in straight lines, and not in regular curves.

The species of trees to plant, and how to arrange and dispose of them so as best to afford shelter and produce landscape effect, &c., must also be duly considered.

Planting may be defined as the work of putting a plant into the ground to germinate or grow. The word is very comprehensive in meaning, and is applied to almost every kind of deposition of plantlet, root, cutting, germ, or seed, whether in the garden, the field, or the forest.

Planting is a work of such vast importance that no information respecting it should be withheld. Nothing short of the most attentive observation, lengthened practice, and protracted experience will enable any one to acquire a competent knowledge of the art and practice of planting. To attain success in it we re-

quire the refined taste of the artist, the foresight of the philosopher, and the skill of the scientist, especially as relates to the laws of physiology. If planting is rightly done, the results throughout will be pleasing and satisfactory; but if wrongly done, disappointment and loss will be the inevitable results. The subject is a comprehensive one, and would take many volumes to exhaust it; but for the present we shall endeavour only to point out the most common and serious errors connected with it, and how to avoid them.

No branch of arboriculture more urgently demands our attention, study, and thought than that of transplanting large forest-trees; and it is only upon close observation of what takes place in nature, and by observing the operations of her unerring laws, that we can reasonably expect success to attend our labours.

In the 'Journal of Forestry' for December 1880, Mr Samuel Neil, Edinburgh, says: "Sir Walter Scott humorously expressed a sentiment of truth when he made the Laird of Dumbiedykes, in the 'Heart of Midlothian,' advise his 'tall, gawky, silly-looking boy,' thus—'Jock, when ye hae naething else to do, ye may be aye sticking in a tree: it will be growing, Jock, when ye're sleeping.'"

To this passage the great novelist adds the following note: "The author has been flattered by the assurance that this *naïve* mode of recommending arboriculture (which was actually delivered in these very words by a Highland laird, while on his deathbed, to his son) had so much weight with a Scottish earl, as to lead to his planting a large tract of country."

Sir Walter Scott invested £5000 in planting and draining, and set his mind to make Abbotsford a proof of the patriotism, the wisdom, the prudence, and the

profitableness, as well as pleasure, of planting. His love of "the good green wood" was found not only in the delight it communicated to his poetic eye, but on his faith in its power to put money into the landed proprietor's purse, and to provide useful employment for the population of rural districts.

He regarded as "indispensable requisites for successful planting: a steady and experienced forester, with the means of procuring at a moment's notice a sufficient number of active and intelligent assistants. Enclosing, planting, pruning, thinning, and felling, are," he said, "going on successfully in different parts of the estate in one and the same year; and these are operations in all of which a good workman ought to be so expert as to be capable of working at them by turns."

The author of 'Waverley' also found time to discuss, describe, and explain the nature, operations, and benefits of transplantation, giving peculiar prominence to the system of Sir Henry Steuart, of Allanton, Lanarkshire; and speaking generally of the transference of trees, he gave it as his opinion that "earlier or later this beautiful and rational system will be brought into general action, when it will do more to advance the picturesque beauty of the country in five years than the slow methods hitherto adopted can attain in fifty."

CHAPTER II.

PREPARING GROUND FOR PLANTING.

The first consideration is, how to prepare the ground for receiving the plants, apart from draining and drying it. One common and efficient way with heath and rough moorland is to take the opportunity, when the ground is dry, to burn it. By law, no moor-burning can be done between April 11 and November 1, so that any other time of the year may be taken advantage of when the herbage is dry. The best time usually is in February, March, and the beginning of April. A slight breeze is desirable; but this is not so important as that the ground be perfectly dry, so that the moss may be all thoroughly consumed. When heath-land has to be dealt with, it should be burned three or four years previous to planting, in order that some herbage may be again grown up to protect the plants, not so much from the winds simply as from snow-drift, and their natural enemies black-game. I have always found trees grow best in heath from 4 to 6 inches high, the plants themselves being from 8 to 10 inches when planted.

Herbage other than heath should be cut once a-year till the plants are fairly above it; and it should be borne in mind that the lateral branches suffer even more

than the top growth from rank herbage: hence they should be kept perfectly clear of everything that can interfere with their development. What is often more difficult to contend with is the matted thick turf that sometimes covers the ground. This matted surface is often 3 inches or more thick, and before the roots pass through it and reach the active soil the plant is necessarily put in too deep for its prosperity. Under such circumstances it is essential that the surface turf be pared off and laid aside before planting.

To pare the whole surface off an acre of ground costs about thirty shillings; and even this sum is worth spending when only small groups are to be planted for speedy growth and immediate effect. In extensive hill-planting, however, this wholesale paring is impracticable; and the next best thing to do is to pare off the surface turf with a sharp spade, turn it aside, and insert the plant in the central part of the bare space thus made, usually about 8 inches square. The turfing may either be done by the planter with his spade as he proceeds, or by a separate person going before with what is termed a breast-spade, and the planters succeeding him.

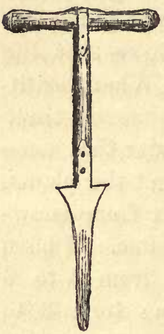

Fig. 1.

In addition to burning the herbage and cutting it for some years afterwards, together with paring off the matted turf that the roots may properly reach their natural soil, another and by no means unimportant operation may with advantage be employed —namely, breaking or loosening the ground with the *forester's footpick* (fig. 1). In using the footpick the operator goes backwards along the

line of direction, inserting the tool three times in each space where the plant is to stand; in effect, making a pit for the plant. The operation produces all the benefits arising from pitting, while it avoids the necessary attendant evils, and is done at a comparatively nominal expense.

In planting ordinary moorland, a man, with a boy or woman to handle the plants, puts in from 1000 to 1200 per day; but when the turf is to pare off in addition to planting, he puts in only from 800 to 900 plants per day with the same assistance.

All excessively bare, smooth, bleak surfaces should be rendered rough and broken, as with the plough, spade, or mattock, so that the plants (which are presumed to be small) should have some shelter till fairly rooted.

Extreme exposures should be planted by using very small, hardy, well-rooted plants, planting them closely together, and thinning early.

The following interesting statement is made by Joseph Bradley, The Hall, Ebberston, York, in the Highland Society's 'Transactions' for 1872:—

"In the month of March those parts of the ground upon which the heather had attained a considerable growth were burned. Some portions of it, however, having been burned some few years ago, and now covered with plenty of young heather 3 or 4 inches high, were not reburned; and from the healthy and luxuriant condition of the trees, it would seem that it would be the best plan to burn the heather three or four years previous to planting, for the young heather affords great protection to the plants. The land being thus cleared, it was then ploughed. The plough used was one of Messrs Ransom's Y.R.C., made of wrought-iron. It was found, however, that each furrow-slice

on trial fell back into the furrow when the plough passed on. In order to obviate this difficulty, an additional coulter was fixed on the opposite side of the beam, the point of which descended to the wing-side of the share in a parallel direction to, and 9 inches apart from, the other coulter. By this contrivance the furrow-slice, which is 9 inches wide and 2 inches deep, is completely cut, and falls on the unploughed land. The furrows are 4 feet distant from each other. Two men (one to manage the horses and the other the plough) are required to work the plough effectually. The quantity of land ploughed in one day of seven and a half hours, with one plough, was 4 acres. The ground, rendered hard by the dry season, filled with the heather roots, which are bad to cut, and in many parts abounding in fast stones, thus necessitating a very slow rate of speed and steadiness, is very difficult to plough, and is very hard work.

"The 9-inch furrows being made, the subsoil plough was then used for breaking the moorland pan and loosening the soil under it. By means of this powerful plough the pan is broken up, not only along the whole length of each furrow, but actually over the whole area between the furrows. This was found to be the case both by examining the pan after the plough had passed, and by the fact of the intermediate ground being tilted up and cracked under the feet of the workmen who walked at the side of the plough. Four men and six powerful horses worked this plough, which in a day of seven and a half hours ploughed on an average 3 acres and 2 roods. When this operation was completed, its good effect was at once apparent. A heavy fall of rain took place, and the land so treated remained perfectly dry, while the adjoining

land of an exactly similar nature, and separated from it only by a wall, was half pond, half swamp, and remained in that state the whole winter.

"In autumn, when the subsoil had been exposed to the action of the atmosphere and become somewhat consolidated, a kind of drag, with three tines and a wheel 6 inches wide on the sole in front, was used for pressing down the soil and breaking the clods. The tines of the drag, descending to a distance of 12 inches, work more effectually when the surface is compressed with this wheel. It pulverises the soil and presses it firmly down, and thus not only is the soil in a better state for the reception of the young trees, but also there is less fear of the plants being lifted by the frost. It is a very valuable implement, and indispensable to the barren land planter. One man with two horses will do 6 acres per day.

"The writer now wishes to show, by giving an accurate statement of the cost of breaking up the ground for the above-named plantation, that the system of planting advocated in this report is not more expensive than those generally in use:—

Cost of previous Ploughing.

Two men, at 2s. 6d. each per day,	£0	5	0
Two horses, at 3s. 6d. each per day,	0	7	0
Wear and tear,	0	1	0
Four acres ploughed,	£0	13	0
Cost of ploughing, per acre,	£0	3	3

Cost of Subsoiling.

Four men, at 2s. 6d. each per day,	£0	10	0
Six horses, at 3s. 6d. each per day,	1	1	0
Wear and tear,	0	4	0
Three and a half acres per day,	£1	15	0
Equal, per acre,	£0	10	0

Cultivating the Furrows.

One man, at 2s. 6d. per day,	£0 2 6
Two horses, at 3s. 6d. each per day,	0 7 0
Wear and tear,	0 2 0
Six acres cultivated a-day,	£0 11 6
Equal, per acre,	£0 1 11

Planting the whole of the Trees.

Labour only—men and boys,	£35 17 6
Taking up trees and couching them on land,	2 10 10
Carriage from nursery to plantation,	3 0 0
Seventy acres planted,	£41 8 4
Equal, per acre,	£0 11 10

Cost of Trees.

123,700 larch, at	13s. 6d. per 1000,	£88 10 0
33,500 "	11s. 0d. "	18 8 6
17,450 Scots firs, at	9s. 0d. "	7 17 0
7,900 "	7s. 0d. "	2 15 4
2,000 pines, at	15s. 0d. "	1 10 0
Total, 184,550	Seventy acres planted,	£119 0 10
Equal, per acre		£1 14 0

Cost per Acre.

First ploughing,	£0 3 3	=Labour only, £1, 7s. per acre.
Subsoiling,	0 10 0	
Cultivating,	0 1 11	
Labour in planting, &c.,	0 11 10	
Cost of trees,	1 14 0	
Total cost per acre,	£3 1 0	

"The advantages derived from the use of this system are—*First,* That the pan is thereby thoroughly destroyed over the whole surface to be planted. *Second,* That the trees are then planted with less

labour than by any of the systems hitherto in use, as the detailed cost given above will confirm.

"By reference to the foregoing table, it will be seen that the cost per acre is £1, 7s.; whereas from information obtained from proprietors in the neighbourhood, who have followed the system of draining the ground by open grips, made about 15 yards apart, the cost was £2 per acre; and for holing and planting at 4 feet apart, the cost varied from £1, 5s. to £2 per acre for labour alone."

In planting ordinary moorland apart from draining, the most important consideration is to remove the rank herbage, old matted surface, and use proper sized plants. I have seen two-year seedlings, one-year transplanted plants, prove an almost complete failure; whereas had the surface been rendered bare, and one-year plants used instead, perfect success would have attended it. Poor moorland, and all ground much exposed, should be planted with the smallest plants possible, provided always that such plants are well-rooted, strong in the stems, and proportionably grown.

Having for years tried many experiments with all sorts and sizes of plants, I have come to the settled conclusion that for general moorland, planting with larch, one-year seedlings one year transplanted are the best, and with Scots fir, two-year seedlings one year transplanted. By two-year seedlings Scots fir, I mean what are now generally known as bedded plants, or plants that are lifted out of the seed-bed when one year old, and laid thickly in close lines for another year. By the process of bedding, a good and important work is accomplished, and one which well repays the labour and expense.

The practice of bedding seedling forest-trees is of

comparatively recent origin, and in some districts, perhaps, is still unknown and unpractised. Several nurserymen, I find, claim the honour of introducing it, which testifies to its beneficial results—for few men care to contend for that which is unsuccessful or unpopular.

In planting deep loamy soil, where the growth is essentially rapid, larger sized plants must be used than for poor and bare moorland. In such cases three- and four- year-old plants may be used ; but they should have been removed in the nursery every year previous to final planting out, in order to form a corresponding balance between root and top growth.

Special attention should also be paid to the development of the branches, and from these the state and condition of the roots may in a great measure be determined. One condition, however, should always be observed—viz., that the plants are clothed with branches close to the ground. From the fact of this condition not being always insisted upon by planters, nurserymen are encouraged to plant too closely in the lines, and even in the seed-beds, which greatly injures the plants by undue crowding. Higher prices must of course be paid for well-grown plants ; but no intelligent man would object to that, as the dearest plants generally prove the cheapest.

The lower branches of a tree are the ones which principally nourish and supply the roots with cambium ; hence the absolute necessity for preserving even the smallest twigs upon seedling and nursery plants, and removing every obstacle to their full and free development, such as weeds, grass, heath, and other herbage.

CHAPTER III.

DRAINING.

The object aimed at with open surface-drains for plantations, is to clear the surface of the ground of all stagnant water, to a depth not necessarily exceeding 12 inches for pine and fir plantation, in order that air may penetrate the soil, raise its temperature, and enable the tree roots to enter and ramify throughout its interstices.

Trees, unlike cereal crops, when fairly established in the ground, perform for themselves a very effective operation of drainage; for no sooner does the tree rise to such height as the wind can move and shake it, than it opens and loosens the soil on all sides, thereby inducing the superfluous water to sink to a depth beyond where it can injuriously influence the growth of the tree. And in other ways trees are very effective in drying the soil at all seasons of the year—viz., absorption by the roots, and evaporation by the leaves.

The best indication as to whether the ground requires drainage or not is probably that of the herbage growing upon its surface. Any one acquainted with natural grasses knows which are produced under the influence of stagnant water, and which are the product of dry soil.

Another good test is that of turning up a spadeful of earth in ordinary dry weather. If it is found pasty and close, it is too wet for the proper growth of trees, and must therefore be drained.

One very decided advantage of draining is produced by spreading the excavations on the surface of the ground; and it is often commendable to put the drains sufficiently close to cover the entire surface with the excavations. The effect of thus spreading the excavations is to encourage in a remarkable degree the roots to run upon the surface. The earth thus spread also induces the natural herbage to decay; and the plants never at any subsequent stage of growth lose the benefits thus conferred on them.

Draining is a work that can well be done by contract, and should always be so done when it can. For ordinary purposes drains answer well put in at 20 feet apart, 30 inches wide at top, 10 inches wide at bottom, and 20 inches deep.

In contracting for a large extent of drains where a diversity of soil exists, and soft mossy parts have to be drained as well, it is most convenient to specify the drains in the mossy ground to be 36 inches wide at top and 2 feet deep. By thus specifying the moss drains to be larger every way two advantages are gained,—one being that the moss ground, which always greatly subsides when the water is extracted from it, receives the benefit of the extra size of drains; and the other, that on measuring the drains, the price being the same throughout, it is not necessary to keep the two classes separate.

One precaution it is specially necessary to observe in laying off plantation drains—viz., not to give them too much fall. There is probably more injury done to plantation drains by want of attention to this, than all

other matters connected with it. The drains should only have sufficient fall to enable them to discharge the water sufficiently, which one in every 300 will enable them to do.

A difficulty of an opposite extreme is, however, sometimes met with in the levelness of the ground and excessive wetness combined. In such cases the most practical thing to do is to lay the ground up in narrow ridges, and by means of the excavations thus taken out of the drains or ditches, the surface can be raised 2 feet or 3 feet above the water-level. The ridges should not be broad, seldom exceeding 20 feet, and 12 feet is sometimes even more suitable.

The fall required for open drains is considerably more than that for underground tile-drains. If open drains require one in 300, underground drains will do well with only one in 500.

Covered drains, though the best, are difficult to keep clear of roots, and the only safe method is to put in as large pipes as possible. In cases where a 3- or 4-inch pipe would sufficiently carry all the water, I would put in a 12- or 14-inch pipe or correspondingly large culvert; and where this has been done the drains have stood well for over forty years, no tree roots choking them.

Annexed are prices which I have paid for plantation drains in Banffshire and Morayshire within the last twenty years:—

Dimensions—30 inches wide,	20 inches deep,		8s. 4d.	per 100 yards.
Do.	do.	do.	6s. 0d.	do.
Do.	do.	do.	5s. 0d.	do.

varying according to state and condition of ground; but in some districts the work can now be done 20 per cent cheaper.

CHAPTER IV.

FENCING.

THE fences in use for surrounding plantations are either wire fences (post and wire strands), turf dykes, stone dykes, or wooden pailings. In erecting

WIRE FENCES,

the straining-posts should be of the very best quality of larch, oak, sweet chestnut, gean-tree, or matured old Scots pine, which latter is as durable as any other description of wood when old and fully matured. The straining-posts for ordinary purposes should be 7½ feet long, 7 inches square, or if round, about 8 inches diameter. The intermediate posts should be of the same description of wood, 5½ to 6 feet long, 3½ inches square, or if round, 4 inches diameter. They should either be sharpened for driving into the ground with a well-drawn wedge-shaped point from 15 to 18 inches in length, or pitted 2½ feet deep.

The tops of the straining-posts should stand about 6 inches above the top wire, and the tops of the intermediate posts about 2 inches above it, and should all be rounded and smoothed for the water to run off. The division between the two upper wires should be

11 inches, and the next spaces respectively 8½, 6½, 6, 5½, and 6 inches between the lower wire and the surface of the ground, making the height of the fence altogether 3 feet 7½ inches.

The cost per 200 yards of finished fence, constructed of the following materials, will be as per estimate:—

	£	s.	d.
2 larch straining-posts, at 3s. each, . .	£0	6	0
100 intermediate posts, at 5¼d. each, . .	2	3	9
6 underground braces, at 3d. each, . .	0	1	6
2 No. 4 wires, at 5s. 3d. per 100, . .	1	1	0
2 No. 5 wires, at 4s. 6d. per 100, . .	0	18	0
2 No. 6 wires, at 3s. 9d. per 100, . .	0	15	0
600 No. 6 staples, at 7½d. per 100, . .	0	3	9
Cost of erecting, at 1¼d. per yard, . .	1	0	10
4 gallons prepared coal-tar, at 4½d. per gallon,	0	1	6
Labour of tarring, at 2s. 2d. per 100, . .	0	4	4
Cartage of material, say	0	2	6
Levelling surface of ground, say . . .	0	5	0
	£7	3	2

Or equal to about 8½d. per lineal yard.

Being all of the very best materials, the cost stated is considerably higher than the work is usually done for, but any one can at once form an approximate estimate from these data.

Straining-posts, with brackets attached to them for the purpose of tightening or loosening the wires, are often of great convenience and advantage, especially upon plantation fences. The brackets are in some cases attached in pairs, one on each side of the post, secured by means of a bolt which passes through it; the head of the bolt secures one bracket, and the other bracket is screwed on by means of a nut. In other cases the brackets are put on singly and secured by means of a flat-headed bolt passing through the post. The brackets possess the advantages of allow-

ing the wires to be slackened or taken off when snow rests upon the fence, when trees accidentally fall upon it, or where temporary openings are required for clearing wood, &c.

Another mode of erecting a strong and substantial fence, for horses and cattle *only*, in districts where no sheep are kept, differs little from that of the former fence, except that the materials are in all respects stronger and heavier. The following are the dimensions found most serviceable in this case, with the cost per 200 yards affixed:—

2 straining-posts, 8 feet long, 8 inches by 8 inches, at 3s. 11d. each, . . .	£0	7	10
8 double brackets, at 3s. each, . . .	1	4	0
100 intermediate posts, 6 feet long, 4 inches by 4 inches, at 6d. each, . . .	2	10	0
6 braces to straining-posts, at 3d. each, .	0	1	6
2 top wires, No. 2, at 7s. 1½d. per 100 yards, ...	1	8	6
2 lower wires, No. 4, at 5s. 3d. per 100 yards, ...	1	1	0
400 staples, at 7½d. per 100 yards, . .	0	2	6
Cost of labour for erecting do., . . .	1	5	0
4 gallons prepared coal-tar, at 4½d. per gallon,	0	1	6
Labour of tarring, ...	0	4	4
Cartage of materials, say	0	5	0
	£9	11	2

Or about 9¼d. per lineal yard.

Two No. 6 wires added to the above would constitute it a fence for sheep of all kinds as well as cattle, if at any time found necessary, at an additional cost of about 1½d. per lineal yard.

In many hill districts the only farm stock kept is sheep, hence fences for them exclusively are necessary. Sheep fences differ from those already described in

the lightness of all materials used, and in the greater closeness of the wires. The following estimate is for 200 yards of sheep fence:—

	£	s.	d.
2 straining-posts, 7 feet long, 6 inches by 6 inches, at 1s. 11d., ...	£0	3	10
100 small posts, 5½ feet long, 3 inches by 3 inches, at 3¾d., ...	1	11	3
6 braces to straining-posts, at 3d., .	0	1	6
1 top wire, No. 4, ...	0	10	6
2 lower wires, No. 5, ...	0	18	0
4 bottom wires, No. 6, ...	1	10	0
4 gallons prepared coal-tar, at 4½d., .	0	1	6
Labour of tarring, ...	0	4	4
700 staples, at 7½d. per 100, . . .	0	4	4½
Cost of labour erecting, ...	0	16	8
Cartage of materials, say	0	2	6
	£6	4	5½

Or about 7½d. per lineal yard.

The great difficulty of fencing against sheep consists in their going through between the wires. They seldom leap over the fence, and as seldom break the wires, but creep through between them. The divisions, therefore, between the wires should be as follows :—

Upper division, ...	9	inches.
Next do.	8	"
Do. do.	6	"
Do. do.	5½	"
Do. do.	5½	"
Do. do.	5½	"

Height about 3 feet 8 inches altogether, allowing 4 inches below the lower wire.

It is strongly recommended that in fixing iron into stone it be done with Portland cement, as by it the work is done much cheaper and more expeditiously than either by lead or by boiled sulphur and sand.

I am against charring the posts as a means of making them last longer, but prefer simply heating the wood, and tarring or pitching it when in the heated state. It is a common opinion that charring posts improves the wood, by rendering it more durable. It certainly does not; but, on the contrary, assists in opening the layers, and admitting air and water to its destruction. Oil of tar or creosote is, however, an excellent preservative, and much preferable to tar or paint.

TURF DYKES

are not unfrequently erected as plantation fences, in preference to others, chiefly on account of the material of which they are composed being convenient and at hand.

It is very commonly believed that the best and most durable turf for dykes is that which contains least solid earth and most vegetable matter, but just the opposite of this is the case. Gardeners, as is well known, in preparing earth for potting their plants, select that which contains most vegetable fibre and least solid earth, and after laying it together for a time, it becomes a decomposed soft and pulpy mass. A corresponding change takes place with turf for a dyke, especially if laid in a horizontal position, one layer above another, as in common practice.

Of two respective dykes built with the same description of turf, the one laid flat and the other set on edge, the latter will be found good and substantial years after the former has fallen down, and perhaps been several times rebuilt.

STONE DYKES

are probably the best plantation fences, and where the stones can be conveniently got, are the most permanent and cheapest material.

In some districts where large surface boulders abound, a rickle dyke, from its construction, is both strong and substantial, and in certain places answers well. In erecting a rickle dyke, a row of the largest stones are laid close together forming the foundation; upon these a second row is laid, observing always that they are made perfectly secure by levelling or pinning with small stones; a third row, and sometimes even a fourth, is required to raise the dyke to the required height, which, for ordinary purposes, is usually about 4 feet. The building of a rickle dyke is neither difficult nor expensive, and usually costs, exclusive of laying down the stones, 3½d. to 4½d. per yard.

The most common of stone dykes, however, is what is termed a double dyke, as distinguished from a single or rickle dyke. A fence of this kind, in very general use for surrounding plantations, is constructed according to the following dimensions and specifications :—

First. The line on which the dyke is to be built must be properly levelled and all loose earth removed from it, so as to secure a firm foundation.

Second. The foundation to be laid with large flat-bedded stones, which foundation must not be less than 28 inches wide at base.

Third. The setting off of building upon the same foundation to be 24 inches, leaving a scarcement of 2 inches upon each side.

Fourth. At 24 inches in height the dyke to have a

row of through band stones, six at least to the rood of 18 feet.

Fifth. The dyke to be built double to the height of 45 inches; and all principal stones in each side must dovetail with those in the heart of the building; and all interstices must be firmly and closely packed.

Sixth. The building at the height of 45 inches to be 12 inches in width.

Seventh. All holes on both sides of the dyke to be firmly pinned with small stones, so as to present a smooth and uniform surface.

Eighth. All stones to be laid on their natural sides with their seams horizontal, and none of a wasting nature to be used.

Ninth. At the height of 45 inches the top of the building is to receive a coat of well-prepared lime, mixed with the usual quantity of sand, as a bed for the cope.

Tenth. When the building is finished as described, a cope of roughly dressed stones 9 inches in depth and 12 in breadth to be properly placed on it, and thoroughly built and pointed with lime.

Eleventh. The entire height of the dyke when finished, and including the cope, to be 54 inches, measuring from the ordinary level of the ground.

Twelfth. The whole work to be finished in a proper and workmanlike manner, to the entire satisfaction of the employer.

The cost of workmanship alone of such dykes varies from 10d. to 1s. 2d. per lineal yard, exclusive of cartage or preparing materials—some even less, and some more.

WOODEN PALINGS.

Various descriptions of wooden palings are also in use, and serve very good purposes in places where they are found suitable.

A common paling is constructed as follows: The line of fence having been resolved upon, and guide-poles set up at convenient distances apart along the line, a garden-line is stretched between the poles, and the posts are driven into the ground or pitted as described for wire fencing, page 20, but not more than about $4\frac{1}{2}$ feet apart. The posts are driven to about 3 feet above ground, and their tops made to run at one uniform level, according to the inclination of the ground. The upper rail is next nailed on, and is kept about $1\frac{1}{2}$ inch below the top of the posts. The rails are sawn out in lengths of about 16 to 18 feet, $3\frac{1}{2}$ to 4 inches broad, and $1\frac{1}{8}$ to $1\frac{1}{4}$ inch thick, according as strength is required. On nailing on the rails they are not necessarily joined on the post, but at any other convenient place, and are overlapped about 8 inches, so that two nails can be driven into each joining to keep it secure. The next rail is put on 9 inches clear between it and the upper one, and the next one 7 inches below that, which leaves a space of $6\frac{1}{2}$ inches between it and the ground. When a four-bar paling is required instead of a three-bar one, the fence is about 4 inches higher, and the rails kept respectively 1 inch closer.

The cost of erecting a three-bar paling, including materials and workmanship, varies from 4d. to 6d. per yard, according to quality of wood, &c.

CHAPTER V.

TRANSPLANTING LARGE TREES.

One curious circumstance connected with transplanting hardwood trees came under my observation about thirty years ago. A farmer having occasion to fix two gate-posts at an entrance to one of his fields, thought proper to use two sycamore-trees for the purpose. Experience having taught him that the heavier the posts were at the base the firmer would they remain in the ground, the trees, instead of being cut down in the usual way, were grubbed round the base, cutting nearly close to the trunk all the principal roots. They were thus lifted with a club base, but without any small roots or fibres; and after being felled, were cross-cut at about 7 feet from the ground, thus leaving that part intended for the gate-posts entirely void of branches, and almost equally so of roots. Holes having been prepared, the posts were put into the ground, in the form of planting. The ground was firmly beaten around them, and the gate hung between them in the usual way. The work was performed about the month of March, and by midsummer the posts began to produce shoots near the top. Next season the shoots were prolonged, and the growth has uniformly continued to the present day.

Though the above system cannot be recommended for removal or transplantation of large trees, yet enough is to be learned from the practice of reducing the top, that certain modifications of it may, with advantage, be carried out in practical operations of planting large trees.

Another interesting case occurred in the parish of Oxnam, Roxburghshire, in the following manner. In the course of erecting the farm-steading of Millheugh, an elm-tree stood in the way. From the size of the tree, and the advanced season of the year (the latter end of June), it was deemed unadvisable to attempt transplanting it. Whilst the workmen were engaged in digging around the tree, with the view of throwing it away, the proprietor, the Marquis of Lothian, an intelligent nobleman, happened to pass at the time, and very courteously tendered his advice, by recommending to lop off a considerable portion of the top of the tree. This was accordingly done; and although the work was somewhat rudely performed by unpractised hands, yet the success was everything that could be desired.

Another instance indicative of the importance of reducing the tops of trees in proportion to the roots came under our observation five years ago. From fifty to sixty trees had at one time been left in a private nursery, and after remaining till they attained from 15 to 20 feet in height, were transplanted in the vicinity of a village in order to produce immediate ornamental effect in the landscape. This took place about twenty-five years ago, and with the greatest success. Owing, however, to subsequent improvements in the place, it became necessary to lift and transplant the whole of the trees, which had now

stood about twelve years in their present situation. On their removal they were carefully dug round in the usual way, their tops reduced, and the whole operations conducted with skill and care, resulting in all the trees growing remarkably well. Again, about eight years subsequently, owing to the widening of a road at the place, it became once more necessary to lift the whole of the trees, and remove them backwards a distance of about 5 feet towards the field side. On this occasion, however, the trees were lifted without any preparation, and planted without at all reducing their tops. The results were, that more than one-half of them either perished or became so sickly that only the very faintest hopes were entertained of their recovery.

Considering the advantages these trees enjoyed by being removed several times previously, and consequently more than usually well rooted, they would almost to a certainty have grown well on their third removal but for want of reducing their tops proportionately. The writer is aware that the operation of top-pruning is objected to on account of disfiguring the tree; this, however, is the result only of unskilful and unpractised hands, and has by no means a bad effect when carefully performed.

Last spring I had the opportunity of observing an elm-tree transplanted in a conspicuous public place; the tree was 14 feet high, and very proportionably and well grown. The work was well performed, and at a good season of the year (the latter end of March). From the moderate size of the tree, its state of growth, &c., success might have been anticipated; yet, sad to relate, total failure was the result! What was the cause of the sudden death to which the tree suc-

cumbed? It underwent no operation preparatory to transplanting, by way of lightening the top, which, if done, would in all probability have preserved it alive.

A Turkey oak of large size, weighing several tons, was successfully transplanted at Cullen House some years ago. The tree was dug round in the usual way at the time of removal, and conveyed to its new situation upon the common janker. It received every attention by watering, and also had some of the largest top branches slightly reduced. It was also well sustained against winds by moorings of cable wire.

Having witnessed the unfavourable results of removing large trees from cold clay soils into soils of different qualities, we were anxious to witness further examples of transplanting under different conditions, such as the removal of trees from a warm dry soil to a cold one, and also of seeing the effects produced by removal from a cold unfavourable soil to that of a favourable opposite extreme.

A small proprietor near Hawick, Roxburghshire, had a number of oaks and other trees taken from a large plantation of about twenty years' growth. The soil of this plantation was a strong red clay, and the trees when lifted had scarcely any earth-balls attached to them. Being for ornamental planting, they were selected with the utmost regard to their form and proportions every way, and were very carefully taken up, so as to inflict as little injury on the roots as possible. The trees were carted to their new destination, a distance of fully ten miles; large pits were dug for their reception, and every possible care bestowed upon them in planting. The soil into which they were planted was loam of various qualities, but far surpassing that of the plantation from which

the trees were taken; yet scarcely half of the trees lived. It was found, on examining their roots a few years after transplanting, that the original ones had completely decayed, and a new class originated from the lower part of the stem. About one-third of the original number planted perished during the first five years after removal, but those that did not succumb are now splendid trees.

During the month of February 1848, a row of trees was planted upon the side of the highway between Jedburgh and Denholm in Roxburghshire. The trees were lifted out of a reserve nursery, and were about twelve years old from the seed when transplanted. The soil in the nursery was loam, rather strong, and the trees on being lifted had their roots considerably bruised and mutilated. The soil to which they were transplanted was a clay loam. The trees, while badly rooted, were equally destitute of branches, having much the appearance, about two years after planting, of May-poles. The side branches, though few in number when the trees were transplanted, had still further diminished. Not only were the branches dead, but the bark of the limes had also become detached, and hung in unsightly shreds, waving in the wind; while the branches themselves appeared white, barkless, bleached, and weather-beaten. Indeed, at that stage, nothing more unsightly in the form of trees could possibly be seen, and many proprietors could not have resisted the temptation of cutting them all down. The line of trees, as originally planted, contained altogether 105; and ten of them died within two years from the time of planting. In the row the trees stood 36 feet apart, and 2 feet out from the hedge towards the fields. The

species of trees comprised sycamore, lime, elm, beech, and poplars, &c.; the greater number, however, are sycamore. The writer having frequent occasion to pass along the highway, took particular interest in watching the progress of this strange, unpromising row of trees. During the first five years after planting, the only signs of vitality were the putting forth a few small shoots at the junction of the dead branches with the stem; and for several winters subsequently the number of dead branches upon them made them still appear as if quite lifeless. In the course of the next five years, and up to the present time, the progress of growth has been quite marvellous; and not only are the stems shooting up, and rapidly assuming the character of timber trees, but the branches are growing equally well, altogether forming, if not magnificent tops, at least handsome and beautiful trees, well formed and proportionably grown. General height of the tree, 20 to 30 feet; girth of stem near the ground, $3\frac{1}{2}$ to $4\frac{1}{2}$ feet, with clean stem 8 feet, which is a very good proportion for hedgerow trees. In this case nature, unaided and unassisted, was about ten years in accomplishing that which by the aid of art she would have done in three years. One remarkable circumstance in this case was the small number of trees that actually perished.

The explanation of this phenomenal success appears to be that the trees were so far deficient in branches as to bring them into fair balance with their roots. The branches upon a tree are arranged and disposed very much the same as the roots are. In this case, however, in consequence of the trees having grown slowly in girth previous to transplanting by standing closely together amongst others, they thus underwent

a supernatural process of pruning and top-reducing, which, to a considerable extent, explains the mystery regarding their growth, which, though exceptionally slow at first, became ultimately so rapid.

In 1858, in the parish of Oxnam, the writer planted a considerable number of trees of various sizes and sorts for ornamental purposes, comprising oak, lime, sycamore, and horse-chestnut. The district was well furnished with pine plantations, but few hardwoods of any sort. Much of the arable land of the district, though in a comparatively high state of cultivation, is nevertheless naturally thin and poor. The subsoil, too, is uncongenial to most sorts of hardwoods. An effort was made to clothe the barren and bare road-sides by introducing hardwoods, which would form a pleasing contrast to the dull pine plantations and square fields around. Two difficulties at the outset stood in the way, neither of which was easy to surmount. The one was a want of the proper sort of trees at command; the other an unsuitable soil. Operations of planting, however, were commenced, and carried out as best they could upon a somewhat extensive scale. The lime-trees were originally grown in an advanced private nursery a few miles distant, with a view of transplanting for immediate effect. The trees were thoroughly well rooted, having been, while in the nursery, several times lifted and transplanted for the express purpose of improving their roots, and were from 8 to 10 feet high, well clothed with branches, and altogether forming handsome trees, and likely to do well. In planting, the pits were duly prepared, soil was taken from the fields adjoining, and put into them to encourage their growth. After planting supports were put to them to ensure stability

against the prevailing winds. At first the trees bade fair to thrive, produced broad healthy leaves the first season, and in some cases small shoots; gradually, however, signs of sickness appeared, the leaves by degrees became smaller, and early in the season assumed a rusty appearance, and became autumn-tinged in August. At the end of autumn, some of them had died down to within two feet of the ground; and when last we saw them, the whole, with only a few exceptions, might be regarded as a failure. The exceptional trees were planted upon deep rich loam, mixed with road scrapings. From the general appearance of the whole trees, the writer was led to believe that the chief and only cause of failure was poverty and coldness of the soil. That the trees grew well at first, was mainly consequent on the sprinkling of good earth borrowed from the fields, which, when once the roots had gone through or exhausted, they languished and ultimately died. The manner in which the failure was produced may be further accounted for from the circumstance that the trees, when in the nursery, were grown upon very good loam, and in a sheltered situation.

Altogether, it might have been feared that the change to the trees must have been unfavourable, but it could scarcely have been predicted that so many of them would have perished.

Throughout the same district other planting was performed about the same time as the above. In corners of fields we planted small groups of trees, composed of oak 8 feet high, spruce 3 feet high, and black Italian poplar from 5 to 6 feet high. Twenty-five years afterwards the oaks were only a few feet higher than when planted; the spruces were about

three times their original height; while the black Italian poplars were from 20 to 25 feet in height, and proportionably thick of stem, and producing altogether a very imposing effect.

The annexed table will show the cost, very nearly, of each tree respectively as it stood transplanted.

COST OF TRANSPLANTING.

Species of trees.	Height of trees.	Age of tree since two feet high.	Number of times removed in nursery before transplantation.	Distance of carriage for transplantation.	Cost of pitting and planting.		Cost of protection.		Value of tree, carriage included.		Total cost of each tree.	
	Feet.	Years.	Times.	Miles.	s.	d.	s.	d.	s.	d.	s.	d.
Lime . . .	10	10	5	6	1	0	1	4	6	0	8	4
Oak. . . .	8	5	1	6	0	9	1	4	2	0	2	9
Horse-chestnut .	9	5	1	5	0	9	1	4	2	6	3	3
Black Italian poplar	5	2	0	15	0	6	1	4	0	8	1	2
Sycamore . .	10	6	1	5	0	9	1	4	3	6	4	3
Spruce . . .	3	1	1	5	0	3	1	4	0	9	1	0

At Cullen House, during the spring 1880, we lifted and transplanted above 200 large hardwood trees of various sorts. The trees were dug round for lifting during the previous winter and spring, and were transplanted in March and April the following year. At the same time that the trees were dug round preparatory to transplanting, their tops were all considerably reduced, which has a very beneficial effect in preventing the trees from blowing down with the wind, which they are very liable to do if at all top-heavy or exposed. Though compelled by circumstances to prune the tops of the trees in winter or spring, the fact must not be overlooked that June and

July is a much preferable time of the year for doing the work.

Notwithstanding the amount of labour and expense attending the transplantation of advanced trees, it is doubtless the best way of raising them, especially hedgerow trees for beautifying the landscape or affording shelter to stock, and will be found to bear a favourable comparison, in point of expense, with that of growing them from small plants or any other way. The losses that attend the transplantation of large trees very little, if at all, exceeds that of planting, or rather growing, small ones.

The writer is so fully persuaded of the advantages, pecuniary and otherwise, arising from transplanting trees from 15 to 20 feet over that of beginning with small ones, that in thinning hardwood plantations he seldom cuts down trees that are suitable for transplanting. Upon all such trees he puts a special mark, known to the woodmen, who leave them at the time of thinning; and afterwards, when convenient, they are dug round, top-pruned, and are thus ready when required for transplanting, and for which there is always ample room on a large estate.

The practice of deep planting is one of the most hurtful that can be adopted, and is always, sooner or later, followed by baneful effects.

Considerable difficulty is often experienced in watering trees to induce the water to penetrate the surface, which becomes caked and hardened after repeated waterings. To facilitate the absorption of the water, it is often advisable to perforate the surface of the ground with a sharp instrument or footpick. As this practice, however, is often attended with results injurious to the roots, by cutting and bruising them,

it is safer, and in some respects better, to insert pipe-tiles into the ground, the upper end level with the surface. The water, when poured into the tiles, soon finds its way to the extremity of the roots. Of all others, the most economic and efficient method of watering appears to be to leave the surface of the ground, at a short distance from the stem, in a depressed or concave form. The water thus rests in the cavity till it sinks down upon the extremities of the roots. It is sometimes asked, What is considered a fair and sufficient watering when the ground is considerably dry? One gallon of water to a square foot of surface may be considered a fair allowance, and administered twice a-week.

In selecting hardwood trees for transplanting, such only should be chosen as have a perfectly healthy appearance. In healthy trees the juices circulate freely, and possess inherent powers of healing, which is of vital importance in case of injuries having been inflicted on the roots, trunk, or branches. A thick fleshy bark, broad leaf, and rich colour, are all important qualities, and worthy of reliance in selecting trees.

In December 1886, the writer planted a number of hardwood trees from 10 to 15 feet high, which remained without supports for some time subsequent to planting. The weather was boisterous at the time, and the wind shook the trees severely, producing around them, by friction, a hole in the earth that admitted water which afterwards became frozen, and the hardened surface of the hole proved very injurious by fretting the bark at the necks of the trees. In a short time, if attention had not been paid to them, the trees would have been completely destroyed; as it was,

they received considerable injury, from which a precautionary lesson may be learned.

In 1853 we assisted in transplanting a group of trees around a newly-built cottage. The group consisted of oak, spruce, and Scots pine, together with some shrubs. The soil was a deep sandy loam, resting upon white sand and clay, at a depth of about 3 feet. The trees were grown in a reserve nursery about a mile distant from the place, and were conveyed thither on carts. Most of them were lifted with balls of earth attached, and were from 6 to 8 feet high. It was observable from the time of planting how well some of the trees grew, making large annual shoots, while others, enjoying the same advantages, made no perceptible progress. The circumstance was so peculiar as to call for special attention; and on examining the roots it was found that those trees which were progressing favourably had been planted with balls of earth adhering, while those of stinted growth had, through accident, lost theirs, which accounted for the discrepancy of growth. Those trees transplanted with the ball of earth attached continued to grow in their new situation as if they had never been removed or disturbed at all; the others, on the contrary, found it difficult to produce a fresh class of roots adapted to their new condition of life.

From the above and similar examples, the writer is persuaded that oaks or other trees planted from clay soils are very uncertain of success, and would therefore seek to guard against such evil consequences as are certain to occur in transplanting without balls.

CONIFERÆ.

Owing to the naturally constitutional difference between coniferæ and hardwood trees generally, it becomes necessary to treat them differently, each according to the laws which regulate their life and health.

The writer has found greater difficulty in transplanting successfully pine-trees than hardwoods—this difficulty arising chiefly from the treacherous nature of the juices or sap of the pines. A slight accident disarranges their sap - vessels, the resin of the tree crystallises and obstructs the canals, and sooner or later causes the life-spring to cease.

One spring the writer transplanted a number of pines and firs which had stood several years in a shrubbery. They had numerous roots, but on lifting them, owing to the loose nature of the soil, the earth all dropped off, leaving them quite bare. Some of them were pruned by shortening their side branches, but none of their tops were assisted. This was done by way of making an experiment to see if the effects were equally favourable, as in the case of hardwoods. In consequence of the severe drought of the succeeding summer, they had all alike to be duly watered, but for which they would probably all have perished. About one-half of those pruned died in the course of the first season, while only about a third of those that were not pruned succumbed. The above trees were planted upon a considerable incline, and upon sandy and gravelly soil; and owing to the declivity of the ground, watering efficiently was very difficult to perform, in consequence of its running off before it had time to sink into the soil. To prevent this, the sur-

face of the ground was left concave a little above and a little below the stem of the tree, with cavities for the water, which gradually sinks down upon the extremities of the roots. When once the tree is fairly established beyond the requirement of artificial watering, the ground may be levelled up and turfed over.

In 1858 the writer had a number of spruces lifted and transplanted which were dug round the year before preparatory to transplanting. They were from 6 to 8 feet high when lifted, and were in a comparatively rapid state of growth, making annually top-shoots from 16 to 20 inches. On examination of the trees five years subsequently, we were considerably disappointed at their unfavourable condition. Though all vital, not one of them was growing fast, the greater number making top-shoots from only 5 to 8 inches, while the foliage was poor and of a light colour. The only assignable cause for the decrease of growth may be ascribed to having grown originally in a soft spongy soil approaching to moss, and their roots, being formed agreeable to that situation, were not adapted to their new one, they having, as it were, acquired a sort of aquatic habit, and having now no further means of thus sustaining themselves, relapsed into their present languishing state.

From the above and other instances that might be cited, it appears absolutely necessary that due regard should be paid to the food a plant is accustomed to, so that, in transplanting it to a new situation, a similar provision shall be made for it. Allowance also should be made for any adverse change or influence that had been brought to bear against the plant. It should, for a time at least, have better food than previously accus-

tomed to, in order to make up for the means of support now so unfavourably altered.

Larch-trees of large size are difficult successfully to transplant, especially those of rapid growth. In making selection where choice can be made, preference should be given to those of comparatively slow growth, provided only they be otherwise sound and healthy.

In transplanting larch, it should be done either in October or a few days before the bud begins to break, and the soil should be dry, pure, light, and open ; they should also be lifted with balls of earth, as without such provision failure is all but certain. In dry summer weather, and especially in autumn, they should be regularly and duly watered for at least three seasons subsequent to transplanting.

In one of the principal Edinburgh nurseries, a few years ago, the writer had his attention directed to a portion of it planted with *Cedrus deodara.* The plants were from 4 to 8 feet high, and transplanted early in spring. About one-half of them presented a very favourable appearance, the others quite the reverse. The ground was all much alike, the plants all of the same stock, and the work of planting done at the same time. The cause of failure in the one case was explained by the earth-ball being broken and the earth shaken from the roots of the plants, which was done intentionally, with the view of encouraging root-growth. Those which succeeded, and without any deaths occurring, were lifted carefully, and planted with the earth adhering. No better or stronger proof than this could possibly be adduced to show the importance of preserving the earth-balls about the roots of plants while in the act of removing them.

In 1857 the writer transplanted large coniferæ

rather extensively and successfully by adopting the following method: Where the plants were found to have earth-balls adhering to them, they were simply transplanted without other auxiliary; but in all cases where the earth fell off the roots in performing the work, he planted them in leaves, at same time watering occasionally, say once a-week.

In 1856 it became necessary, in the month of June, at Pippinford Park, Sussex, to remove several pines and large shrubs. In performing the work, the earth was entirely disengaged from their roots. They were, however, all planted in leaves, and grew well.

During the summer of 1868 we had occasion, in the month of July, to lift sixty silver firs from 10 to 15 feet high. These we planted in a heap of leaves, and without any other attention they all, with two exceptions, struck root and grew well. The success that attended the preservation of these trees was all the more wonderful, considering that they were removed without almost any earth adhering to them, and at a time and season so remarkable for its excessive heat and drought, that thousands of plants long established in the ground withered and died. Even some of the silver firs referred to were at the time of removal suffering considerably from the effects of the drought, but on removal recovered, and are at present, in another situation, growing and quite healthy.

Another circumstance connected with planting in leaves is worthy of notice. In a reserve nursery, a number of trees, from 6 to 8 feet high, were lifted for the purpose of transplanting, but being considerably overgrown, the best only were selected and the others cast away, being carelessly thrown over the fences as useless. A quantity of leaves accumulated about the

roots of the plants thus thrown away, which induced them to strike root, and were found afterwards in a better state of health, making more rapid growths than those which were carefully taken up and planted with skill and attention. This is another proof of the power and virtue which leaves possess of encouraging and producing root-growth, their chief virtue consisting in the moisture they retain and food they afford.

In selecting

HARDWOOD TREES

for transplanting, it is desirable to take them from a higher to a lower altitude, from a poorer to a richer soil, from loam to clay rather than from clay to loam, from an open to a stiff, from a cold soil to a warmer one, and from exposure to shelter. These conditions, however, apply more to the future success than to the immediate growth of the plants. The form and habit of the tree should be duly observed in making selection, and choice had of such only as are of free but not luxuriant growth, having a clear fleshy bark, full and well-developed buds. Of the gummy sorts of trees, those should be preferred that are most gummy, and others whose buds are most fully developed. It is better to select those trees which have numerous small branches, with stem thick at the base, and gradually tapering towards the top, with branches diverging from the tree horizontally, rejecting those whose branches are vertically inclined.

In selecting

PINES

for transplanting, choice should be made of such as are of somewhat slow growth, stems straight, and uni-

formly tapering from foot to head, and clothed from top to base with rather slender branches, clean healthy bark, and rich and dark foliage. In other respects the same conditions are applicable as for hardwoods generally. As the larch, however, differs so widely in its growth from both hardwoods and pines, it requires different treatment. How far the larch will submit to pruning, so that when transplanted the balance of growth may be so maintained that the roots will be able to sustain the tree, is still a matter of some uncertainty.

In preparing trees for transplanting, a trench should be dug around them, describing a circle somewhat within that of the outer extremity of the branches. The trench should be made sufficiently deep to cut all the roots, and then filled in with earth, fresher and richer, if possible, than that dug out. After being dug round, the tree should be allowed to remain one, two, or three years, according to circumstances, when it will be fit for removal; but if not removed at the end of three years, a second digging will be found necessary, and should be done in such a way as to keep clear of the last-formed trench, and thereby avoid cutting the newly-formed fibres. When the circle described around the roots is necessarily too small compared with the spread of the branches, the latter should be reduced in due proportion, otherwise the roots will be unable to nourish the whole tree. Digging round and preparation of the roots should be done in spring, while pruning the top should be performed in summer, at least one year previous to transplanting.

In consequence of the almost unavoidable disengagement of earth from the roots of the trees in the process of transplanting, a necessity is thus in-

duced of artificially aiding them in obtaining sufficient nourishment in their new situation; and as the food of trees, as of all other plants, is only absorbed in a soluble state, this must be done by plentiful watering. Moist leaves, with a sprinkling of sand amongst them, are probably the best ingredients as food to apply to a newly transplanted tree.

In preparing the pits for receiving the trees, they should be made one-third larger than the ball of the roots which is to fill them. The subsoil also should be loosened for a considerable depth; and when water occurs in the bottom, a stone or tile drain should be introduced to carry it off. September and October are the best months of the year for transplanting generally, but April and May have certain advantages also.

The expediency of reversing the position of trees in their new situation, such as placing the seaward side landward, and landward seaward, is a questionable practice. The benefits arising from it are more than counteracted by the injurious results. The art of transplanting is now much better understood, and its mysteries cleared up, than in bygone days, yet much has to be learned in order to obtain definite results and true success.

In the act of transplanting where watering is required, it is better to pulverise the earth and fill the pit with it while dry and loose, and afterwards fully saturate it with water, than by beating or tramping the earth in a wet state. In substituting new and fresh earth for that taken out of the trench, in order to introduce that which is most adhesive for removal, it should be largely composed of turf-mould, taken from a clayey soil, and well mixed with leaves or other fibrous substances which adhere to the roots.

CHAPTER VI.

SUCCESSIVE CROPPING WITH SCOTCH FIR (*PINUS SYLVESTRIS*).

Mr William M'Corquodale makes the following statement of his experience, which I prefer giving from his pen rather than my own, as his authority on this subject stands high :—

"In 1843 we finished the cutting of an old Scots fir plantation, extending to about 100 acres. Early in spring I got a hundred Scots firs planted in it, fifty of which were slitted into the ground, and the other fifty carefully pitted, breaking the surface well into the bottom of the pit, and the stiff clay taken from the bottom filled in last upon the top, when it was smoothed over with the back of the spade, to prevent the beetle lodging about the rough surface. This was done one year, before the ground was prepared for planting, with the view of ascertaining which would be the most advantageous method of planting the whole ground the ensuing year.

"Upon examining the above plants the following autumn, along with my employer, he saw at once the propriety of planting it wholly by pitting. Those of the plants which had been slitted into the ground were entirely destroyed by the beetle; whereas the

pitted ones were healthy and vigorous, made good progress, and stood quite uninjured.

"In spring 1844 the whole of this plantation was planted by pitting with Scots fir. The pits were opened by contract, 4 feet apart, being 3422 pits to the Scots acre, at the rate of 30s. 10d. per acre. The plants were planted into the pits by men on day's wages, which cost 15s. per acre, making a total of 45s. 10d. expense per acre for planting. The pits were in size 15 inches in diameter and 10 inches deep. The surface was carefully broken and mixed with the best of the soil into the bottom of the pits, and the clay taken from the bottom was filled in last. The clay on the surface remains a long time clean, and free from any foulness growing into it. The pits were well trodden down and beat with the back of the spade, in order to smooth the surface and prevent the beetle harbouring in them, which it would do were the surface rough. Five acres of this plantation were at the same time planted by slitting, to see how they would succeed. At the end of the season they proved a total failure, having been wholly destroyed by the beetle during the summer. The pitted ones, on the contrary, remained uninjured, and appeared quite healthy and strong. During winter, however, they suffered much; having been planted in a tract of moorish land with very retentive subsoil, about 30,000 of the pitted plants were thrown out by the frosts of winter. The following spring their places were supplied by fresh plants, and all have done well since.

"In spring 1846 an old Scots fir plantation of twenty acres, upon the estate of Innernytie, was cleared out for planting. Being a flat piece of poor

moorish land, and being thickly studded with Scots fir stools, I was satisfied that Scots fir was the only crop of trees that would grow to profitable timber upon it. At the same time I was much at a loss how to proceed in planting them; for if pitted, the frost would throw them out in this description of soil; and if slitted into the ground, the wood-beetle would destroy them. How, then, were they to be planted to escape the twofold danger?

"The following was the mode of planting I adopted, and which, I am happy to say, has proved the most successful method of any hitherto adopted.

"The planter, by turning the face of the spade towards him, makes a perpendicular cut down into the ground about a foot long; he then makes another cut across the centre, holding the spade in the natural way, and placing it 4 inches back from the first cross-cut, the spade is thrust down.

"The planter then takes the plant in his hand, gathering up the branches, and pressing the handle of the spade towards the ground, he slips the root underneath the spade, and moving the plant forward, makes it stand erect in the first cross-cut. The ground is then well but carefully trodden down around it; and lastly, three large spadesful of earth are taken about two feet back from the plant and laid down around its neck, forming a layer of about 15 inches diameter round the plant. This layer of earth must be likewise firmly trodden down and beaten with the back of the spade to smooth the surface, in order to prevent the beetle lodging about it.

"Such was the manner in which I planted up this piece of ground. The plants were put in 4 feet apart. The expense of planting this plantation, by slitting and

earthing around the necks of the plants in the manner above stated, amounted to 22s. per imperial acre.

"In the above planting of 20 acres there was scarcely a plant failed; but if, perchance, a plant was found that had been neglected to be properly earthed, it was either devoured or rendered useless by the beetle.

"In 1851 we finished the cutting of 27 acres of old Scots fir, which was immediately after thoroughly drained. The drains were laid in at 36 feet apart, and 2½ feet deep. The castings from the drains were laid in equal quantities on each side of the drains, for the purpose of securing earth conveniently from them for earthing the young trees during the planting operations. After this plantation was cleared and drained, it was allowed to stand over for a year before it was planted, on purpose to rear up as rank a crop of herbage as possible; and early in March the herbage was carefully and effectually burned all over, with the view of destroying the eggs of the beetle.

"The ground was all planted up immediately (after having been burnt) with strong two-years' transplanted Scots fir plants, at 4 feet apart, and the plants were all earthed from the castings of the drains. The cost of planting per imperial acre amounted only to 15s.

"Of all my experiments in planting with young Scots fir, after previous old Scots fir crops, the above has been the most successful, and above all others is the mode of planting I recommend to other planters.

"After a crop of Scots fir is cleared away, the whole ground should be effectually drained, if necessary, at 36 feet apart, and 2 to 3 feet deep, as may

best suit the nature of the soil. The castings from the drains should be laid down in equal quantities on each side of every drain, for the convenience of furnishing earth for earthing the plants.

"After the ground is thoroughly and effectually enclosed, and all brushwood has been cleared out, the ground should be permitted to lie over for at least one year, during which time the ground should be strictly protected from being pastured by stock of any description, in order to rear up as rank a crop of herbage as possible. Early in March, in dry weather, the whole herbage should be carefully burned all over the ground intended for planting.

"The drains will keep the burning within bounds, and with a little care and caution it may easily be prevented from overrunning to any adjoining cover.

"After the operation of burning is completed, the planting should be proceeded with immediately. And to withstand the beetle and to enable the plants to get speedily beyond the risk of being attacked by it, I would recommend strong two-years' transplanted plants, which, if carefully planted on the system of double slitting, as already described, with a substantial layer of earth, will keep clean for a long period; and if the work is carefully performed, the plants are secure from the beetle. Independently of protecting the plants from the beetle, this layer is very serviceable in supporting the young trees, and preventing the summer droughts from opening the slits. If the plants are healthy and strong when planted, they will, by the second year, be beyond the reach of being much damaged by the insect.

"We have planted several hundreds of acres with young Scots fir, after old Scots fir crops, within the

last twenty-five years, in different counties; and I venture to assert that these plantations will bear comparison with any plantations in our country that have been planted on new soils of equal quality."

Mr M'Corquodale's position and experience well entitle him to speak on such a subject with much authority, and it will be found that what he states as the actual results of his experiments are perfectly in accordance with facts.

With all due deference, however, to his theory regarding the wood-beetle's depredations, I am certain it will be found that the beetle only attacks unhealthy plants and not healthy ones, and the producing cause of the dishealth is that of planting in the old effete vegetable matter. This is even borne out by what Mr M'Corquodale states, both in regard to herbage burning and egg-destroying by fire, and by turning up fresh soil, either in the form of pitting, as clearly described, or by using the excavations from the drains or other alternative of borrowing a little soil to lay round the plant: any or all of these expedients may safely be adopted, and the results will be found equally satisfactory in them all. It is of small moment how the old surface is cleaned, if only it is so, and the plant kept clear of it, so as not to vitiate the health of the plant. Where the surface can be thoroughly burnt, and thereby cleaned and sweetened, no better or cheaper plan can be adopted; but where this cannot be effected I prefer draining and using the excavations; but my system in doing so is first to pare off the turf where the plant is to stand, and by adding a spadeful of the excavations the surface is thereby not only brought up to the level of the surrounding ground,

but raised an inch or so above it, and the roots of the plant are so placed in notching in as to remain partly in the solid ground and partly in the earth supplied. Great care, however, is required in any case to see that no plant is put in more than half an inch deeper than it stood in the nursery ground.

CHAPTER VII.

MARITIME OR SEA-SIDE PLANTING.

No. 1 is a plantation upon the coast of the Moray Firth, in Morayshire, composed of Scots pine and larch, known by the name of Bog Moss or Culbin Sands. It is situated to the west of Forres between one and three miles, extending along the shore, and inland about one mile. Culbin sand-hills is an extensive tract of shifting sands, or rather was such thirty years ago. The sand-hills referred to, previous to planting, comprised altogether 3370 acres—literally a wilderness of shifting sand of various depths, from 3 or 4 to 120 feet or upwards.

What now constitutes Culbin sand-hills is said at a past period to have sustained the distinction of "the granary of Moray." This appellation was conferred in consideration of the richness and fertility of the soil.

Tempting though it is to revel amongst the sand-hills, the origin and formation of which, together with their subsequent changes and various phases, are so full of interest, the writer must here be content to describe only what has been done and is still doing upon their surface, by way of turning them to economical and profitable account by means of planting.

Between forty-four and forty-six years ago the re-

doubtable late "Mr John Gregor, nurseryman, Forres, conducted the planting of about 300 acres. The work was performed mostly by contract, and executed by two or more separate companies of planters (men and women). The men, by themselves, did the most difficult parts, and the women the easier wrought ground. Each person carried his own or her own plants in an apron, and used the small planting spade for nicking or rather opening the sand to admit the plants, which were small. The rates of wages paid to the planters were 1s. 6d. to 1s. 8d. per day to the men, and 8d. to 10d. per day to the women."

The plants consisted of Scots pine and larch, put in in various proportions—sometimes one-third larch, and sometimes more than one-half. About 4000 plants were put in per acre, and the whole cost an average sum of about 14s. per acre, as follows :—

2000 larch one-year seedlings, one year transplanted, at 3s. per 1000	£0	6	0
2000 native Scots pine one-year seedlings, one year transplanted, at 2s. per 1000, .	0	4	0
Expenses of planting, ...	0	4	0
Total per acre, ...	£0	14	0

The writer has frequently been asked to recommend as to the planting of certain unfavourable sites upon the coasts of the Moray Firth; and the following answers to inquiries, after hearing the particulars given, may be serviceable to those requiring to do such work :—

No. 1.—Full exposure to the German Ocean; slope of ground towards the sea; no shelter of any kind, either caused by undulations of the ground or herbage; soil sandy and shifting by the wind.

Answer.—Such a subject cannot be planted so as to produce either shelter, ornament, or profit, unless with sea-buckthorn, which I have never seen fail.

No. 2.—Site of plantation upon a plain, elevated a few feet above high-water mark; soil sandy above, but stiff and mossy underneath; exposure open to the sea northwards; no natural shelter afforded.

Answer.—Erect a wooden paling 3 to 4 feet high, and between two sets of rails place brushwood to form a screen 4 to 5 feet high. Along, inside the screen-fence, plant buckthorn, strong well-rooted plants, and cut off their tops to half their original height. Next to the screen the plants may be planted 3 feet apart, and gradually increase in distance to 5 feet. The belt of buckthorn may be 20 feet wide or so. The next belt farther landward may be elder, planted 5 feet apart, and of a breadth about equal to the buckthorn.

The next zone may be aspen or wild poplar, mixed with snowberry, the former planted 10 feet apart and the latter between them, of the same number, making the whole up to 5 feet apart.

The next zone may be a mixture of sycamore and mountain-ash, if the soil is suitable for growing wood of useful size; but if, on the contrary, it is very sandy and poor, instead of sycamore, the goat-willow may be planted amongst the mountain-ash. It may be as well to plant the buckthorn in a belt all around the plantation, but less broad at the least exposed parts.

This plantation, be it observed, is recommended only for the sake of shelter and ornament, and may reasonably be expected to fulfil both purposes.

No. 3.—Exposure to south-east and north-west, but sheltered from due north; soil generally light loam, but

hard and gravelly in places; ground undulating, and sloping slightly towards the land side. The surface of the soil is covered with a variety of grasses, which are of some value for grazing; hence, if recommended for planting, profit will be looked for.

Recommendation for planting No. 3.—First, the outside belt on the exposed side may be buckthorn 10 feet broad, and the plants at the margin planted 2 feet apart to form a hedge; the second belt to be goat-willow, mixed with mountain-ash; third zone aspen, poplar, and sycamore; and fourth zone, sycamore and oak, and where the soil is good, instead of sycamore ash and elm may be substituted; the whole ground made up to 5 feet apart. If cover for game is also required, common sea-buckthorn may be intermixed throughout, varying at distances apart of from 5 to 10 feet.

The above plantation constitutes what may be properly termed a maritime or sea-side plantation; and the trees and plants of which it is composed are such as to allow a variety of objects to be carried out.

The reader will probably feel surprised at no mention being made of coniferæ, and no place being assigned to any of them. The reason of this is, that the foliage of evergreens suffers so greatly in winter as to cause them invariably to become bare and unsightly, besides presenting at all times a withered and burnt appearance, which is not experienced by hardwoods to any serious extent; and besides, when hardwoods do sustain a blight, which frequently happens, a little judicious pruning soon corrects all that is wrong. If, however, it is found desirable to plant for sake of winter shelter, we would recommend as the best which we have tried the following in order: (1) the best

for sake of shelter is the *Pinus austriaca*, (2) *Pinus pinaster maritima*, and (3) the common silver fir.

Recapitulation of trees and shrubs best adapted for planting within the influence of the sea-breeze, beginning with deciduous trees, and taking them in their order of merit, considering them more in their adaptation to maritime situations than their usefulness as timber or mercantile products:—

Trees.—1. The trembling poplar (*Populus tremula*); 2. The goat-willow (*Salix caprea*); 3. The sycamore (*Acer pseudo-platanus*); 4. The mountain-ash or rowan-tree (*Pyrus aucuparia*); 5. Wild cherry (*Cerasus sylvestris*); 6. Common ash (*Fraxinus excelsior*); 7. The wych-elm (*Ulmus montana*); 8. The oak (*Quercus*).

Amongst coniferæ, the following are considered the best:—

Trees.—1. *Pinus austriaca* (Austrian pine); 2. *Pinus pinaster maritima* (maritime pine); 3. *Picea pectinata* (silver fir); 4. *Pinus sylvestris* (Scots pine); 5. *Pinus laricio* (Corsican pine); 6. *Pinus Douglasii* (Douglas spruce).

Shrubs, in their order of hardiness:—

1. Sea-buckthorn (*Hippophaë rhamnoides*); 2. The elder (*Sambucus nigra*); 3. Snowberry (*Symphoricarpus racemosus*); 4. *Spiræa adiantifolia*; 5. Evergreen barberry (*Mahonia aquifolium*); 6. The tamarisk (*Tamarix gallica*); 7. The Scotch rose or brier; 8. Sweet birch; 9. Hawthorn; 10. The goat or mountain willow.

In connection with planting any of the preceding list of trees or shrubs, very special attention is called to the state of the ground, which, if unsuitable, must either be improved, or failure will to some extent be the inevitable result.

CHAPTER VIII.

PLANTING BARREN AND EXPOSED DISTRICTS.

AMONGST the coniferæ found suitable for withstanding sea-breezes and exposures on coasts are the following: *Pinus montana, P. pumilo, P. pinaster* or *maritima, P. austriaca, P. sylvestris,* and *P. laricio,* and the silver fir, *P. pectinata,*—all have severally succeeded very well.

Of the hardwooded sorts, undoubtedly the best to withstand wind in any situation is the plane-tree or sycamore (*Acer pseudo-platanus*). Its branches being "twiggy," it resists the gales with greater impunity than any other, and forms a fine round head under any disadvantage of exposure.

Several of the poplars also do well, notably the *Populus tremula;* several of the alders in wet situations or soils, as *Alnus glutinosa,* and the hoary alder (*Alnus incana*), Norway maple (*Acer platanoides*), and many of the numerous members of the willow (*Salix*) family. In sandy soils, or indeed in pure sand, the goat-willow (*Salix caprea*) is an excellent variety to plant; also the Huntingdon willow (*Salix alba*) and the mountain-ash (*Pyrus aucuparia*). Birch, ash, elm may next in order be named, and lastly, oak and beech. The last mentioned, however, is least

suited for planting in such situations, or near the influence of the sea-breezes.

Mr Joseph Bradley, The Hall, York, in the 'Transactions of the Highland and Agricultural Society, 1872,' gives the following statement:—

"The piece of land that forms the basis of this report was prepared and planted in the autumn of 1869, and in the winter of 1870. It is situated on a high ridge between two valleys which run north and south in the parish of Allerston, in the North Riding of the county of York, and is about ten miles from the sea-coast. Its altitude, according to the Ordnance Survey, is 610 feet. It contains an area of about 70 acres, and is thoroughly exposed to every quarter, with the exception of a small part of it at the north-east corner, where it is protected by the end of a narrow plantation of about fifty years' growth, composed of larch, Scots and spruce firs. The surface soil of the 70 acres is black and peaty, about 3 inches in depth, and was covered with stunted heather. Below this is a hard gravelly soil, varying from 2 inches to 1 foot in depth, and resting on the pan. Below the pan is found a yellow sandy subsoil, resting on the oolite limestone of which these hills are formed.

"*Planting the prepared Soil.*—To plant the quantity of land, which was about 70 acres, twelve men and seven boys are employed.

"The number of trees planted on 70 acres of land was 157,200 of larch, 25,350 of Scots firs, and 2000 of Corsican pines—total, 184,550. For a space of 50 yards to the north-east and west sides of the ground, the trees were planted 3 feet 6 inches apart, and the remainder 4 feet apart. On the north side

one Scots fir was planted to three of larch; on the other portion one Scots fir to twenty-four larch. About 2000 Corsican pines were distributed all over the ground in place of Scots firs. The greater part of the trees—supplied by Messrs John Grigor & Co., Forres, and Messrs Drummond & Son of Stirling, N.B.—were one-year seedlings one year transplanted, and replanted into our own nursery ground for one year. They had fine fibrous roots, and were only taken up about a day before replanting. The trees have grown remarkably well; most of them have pushed out many fine lateral branches from 3 to 4 inches long, and leading shoots from 3 to 6 inches long. The number of dead trees in the whole piece of ground is about 3000 out of 184,550. The fact of the small number of deaths, viz., 3000, and considering the dryness of the season of 1870, shows that the result of this new system is decidedly encouraging. And on this account 120 acres are being prepared for planting during the forthcoming season."

Mr Alfred J. Burrows, Pluckley, Kent, in his report to the Highland Society, 1880, says:—

"All things being prepared, the forester will choose his weather, and divide his available staff into raisers, pruners, carriers, and planters, in numbers proportioned to the requirements of the several operations. The raisers will commence by opening a trench alongside the first row of trees to be raised, and a little deeper than the roots penetrate, and so completely loosen the soil that the plants will come out without force, and with their roots intact. This operation must be repeated for every succeeding row until all are raised. By proceeding with great care very little root-pruning will be necessary. But where the tap-roots have not

been previously undercut, they should now be shortened, and any injured roots should be removed. Immediately this is done, immerse the roots and a few inches of the stem in a puddle of clay and water, of such a consistency that it will stick well to them. Whoever has paid much attention to the structure and functions of roots, and has observed that it is through the spongioles at the ends of the slender fibres—and through these alone—that the plant obtains its nourishment from the soil, will hesitate before cutting back a single root. The larger roots are covered with an epidermis or skin, which in older trees becomes thickened into a cortical integument like bark, and are quite destitute of pores.

"Though root-pruning is a custom 'more honoured in the breach than the observance,' yet it will often be necessary to prune back the head of a plant so as to start it on its course with a fair chance of success. This will be desirable when, from injury or otherwise, its root-growth is greatly disproportioned to the size of the head. To replant it in this state would be to start it on its course too heavily handicapped, and sooner or later it must succumb. By a judicious lightening of the head, and thus adapting its requirements to the power of the roots, the equilibrium may be restored, and such shoots only will be produced as the roots have power to support. The neglect of this precaution is the reason why, in a new plantation, so many of the trees shoot only from near the ground, or break out in sprigs a little way up. But such pruning as is here recommended requires great care and judgment, and should only be intrusted to experienced hands. Besides, as it can only be practised in the case of decidu-

ous trees, it ought to ensure all the more care being taken in raising the coniferous kinds."

During their removal, all plants should have their roots carefully covered; and where bedding-in has to be resorted to, choose moderately dry and warm ground. In the case of Scots and spruce firs, and other persistent-leaved kinds, spread them out thinly in the lines, or mouldiness will follow. The roots should in all cases be embedded in tolerably fine soil.

Where the plants are small, and the system of notching-in is practised, the marker goes forward, and by a cross-cut of his spade indicates the position of each plant. The planter who follows strikes the point of his spade or diamond-dibble into the ground at one extremity of the cross, and to a depth proportioned to the requirements of his plant, and then depresses the handle, upon which the ground opens at the centre of the notch, wide enough to allow the boy or carrier to insert the plant. By withdrawing the spade after adjusting the roots the ground closes, and a slight pressure of the foot completes the operation. In this way a man and boy may plant from 1200 to 1500 trees per day. Where small plants are used, and the land is of a nature to require the use of the planting mattock, the ground is well loosened, and the larger stones removed from the hole, after which the operation is completed with the aid of the planting hoe, a light treading being necessary to finish it.

In planting into prepared holes, water should be let off, and the bottom should be well stirred and loosened: the addition of compost, or some burnt soil, will prove invaluable. In making such additions, the object should be to meet the requirements of the in-

tended crop, and cause the new position to assimilate as much as possible to the old one. Where the turf is not to be replaced around the stem, it is better to chop it finely and put it in the bottom of the hole, as it seldom settles firmly above the roots. While the tree is held by a boy in an upright position, the planter shakes over its roots some of the finest soil within his reach, and by gently moving it up and down, every crevice is filled. At the same time care should be taken to feather out the roots by hand, to distribute them evenly throughout the whole soil, and put them in their natural positions. This system will place them under the most favourable circumstances for obtaining their regular supply of food, and will be most likely to ensure permanent stability.

No treading should be allowed except upon very light soils, and even there the operation is better deferred till some days after planting. To stamp heavily upon wet earth or clay immediately it is placed around the roots of trees, is to encase them in an almost impenetrable mass of soil, from which their tender fibres can derive little or no nourishment.

In situations of great exposure it is a common practice to place the tree in one corner of the dug hole, giving it the support of the unmoved ground on its leeward side. But as in such a case the roots must all be spread out on the opposite side, and will consequently make their most vigorous growth in that direction, while they will be very slow in penetrating the firm soil, the practice is not to be recommended. In the well-trenched nursery grounds it may be advisable; but where, upon very firm soils, holing alone has been the preparation, its advantages are very questionable.

Upon light and stony soils the stones are sometimes placed around or near the stem of the plant, to counteract the loosening effects of frosts. It is necessary at all times to prevent rocking, as no satisfactory root-growth can be made while this continues; hence the disadvantage of using plants which have stood very close together in the nursery lines,—their growth is not sufficiently robust to fit them for exposed places.

In conclusion, we cannot too strongly insist upon the necessity of a proper preparation of the ground, a judicious selection of trees, and of weather for removing them, and careful handling in every operation. By strict attention to these the planter may rest satisfied that though " 'tis not in mortals to command success," he'll " deserve it."

CHAPTER IX.

PLANTING IN FOREIGN COUNTRIES.

"TREE-PLANTING is now receiving much attention in the Far West, and California appears to be going ahead in this useful pursuit with her accustomed energy and success. The 'blue gum' of Australia (*Eucalyptus globulus*) seems to be the favourite tree with extensive planters,—Mr James T. Stratton, of Almeda County, having had planted, more than a year ago, 130,000 trees of it, and the Central Pacific Company 50,000, as a first instalment of a million they intend to plant along the line they own, their immediate object being to increase the humidity of the region and lesson the liability of droughts. Other railway companies and private individuals throughout the State are also planting largely the same valuable tree, which promises to become in sub-tropic countries as useful and remunerative to the inhabitants as are the fir, larch, and pine in more temperate climes.

"The subject of tree-planting is one that is at present attracting considerable attention in the Cape Colony. Every country that is subject to periodical droughts is too poor to neglect planting. In this point of view, it is absolutely necessary to utilise every possible means of increasing rainfall and retaining moisture. In old

Dutch times at the Cape, a law required every landed proprietor to plant a certain number of trees per *morgen*, and as a consequence Capetown and Stellenbosch are now supplied with noble oaks, stately avenues, and shady walks. It must be admitted, on the other hand, that in the eastern districts of the Cape Colony tree-planting has been shamefully neglected. We are glad, however, to be able to report that in this respect a change is taking place. The Divisional Council of Albany has resolved to plant the sides of all their public roads with trees. The city of Grahamstown has been immensely improved by judicious planting; and everywhere—in villages and at farms—tree-planting is in course of being carried out successfully.

"In M. Renard's estate of the Park of Enbas, near the town of Houdan, the returns from root-crops were small and irregular, only obtainable after large and constant application of artificial manures, while the frost of a night or so might destroy the husbandman's hopes for the season. Some clumps of *Pinus sylvestris*, whose height reminded one of its stately magnificence in Norway and Sweden, standing in 400 acres of moorland of the 700 acres or so of the estate, determined the new proprietor, in 1867, to devote the whole area to sylviculture, and he has since systematically pursued such a policy with profit, besides adding a thousandfold to the amenity of his summer residence.

"Wood's reaping-machine, driven by two horses, effectually cleared the ground of heath and furze. The area was next traversed by a horse-rake, to sweep up the detritus, which made excellent fodder. Under this heath was a subsoil, mostly of very fine sand, with little iron. This was turned up by a heavy subsoil

plough; the furrows were perfectly and regularly made, whilst the great balls of earth which bound together the roots of the moor plants, now cut down, were disintegrated, so as to loosen them.

"Pines were mostly sown. As much as 10 kilogrammes per hectare were used of seeds of *Pinus sylvestris*, which was diversified with 12 kilogrammes per hectare of a mixture of *P. sylvestris* and *P. maritimus*. The ground so sown was harrowed to ensure regular germination, which was very apparent in the second year. But birches—useful for charcoal in the seventh or eighth year after sowing—were also extensively sown, as were alders.

"Adding beauty to the landscape was a prominent object, as well as profitable, in carrying out the estate improvements. And here the success is very marked. Numerous avenues of different species of noble trees tempt alike the pedestrian and horseman; while diversified sheets of water, with curious islets, add variety to the scene. In such moist spots great beds of osiers grow, profitable both for the periodic crops won from them, and for the shelter they afford to numerous birds whose songs break the sylvan stillness. In the flowering season rhododendrons, azaleas, kalmias, and other rare exotic shrubs add unique beauty to their joyous surroundings. Besides, the climate is better; the neighbouring barley or buckwheat is no longer browned in a night, and regular showers of rain can now be depended on. Country life is enjoyed, without carking care about weather and crops.

"The returns are ample on the capital expended. Altogether, M. Renard has spent about £20,000 on the property; he has been offered £25,000 for, and refused it."

CALCULATIONS OF COST OF GROWING PINE TIMBER.

"Mr Sonson, a highly intelligent Norwegian gentleman, who has made a large fortune in the timber trade, informed me some time ago that, according to a calculation which he had made, pine and spruce timber actually costs and is worth much more than the price at which it is sold. His theory is, that an acre of grown timber is worth the sum that the lowest or nominal price of wild land—say, £1 an acre—would amount to as an invested capital, drawing interest at the expiration of the period required for timber to develop. In the report, 'Swedish Forest Culture,' it was shown that in the northerly parts of Sweden, two hundred years, and on poorer soils three hundred years, are required for the growth of pine timber. In the south part of the country one hundred years are sufficient. It may be assumed that one hundred and eighty years are required for the growth of pine timber in the north-west part of the United States. Now £1 invested at 5 per cent interest per annum will double, say, in twenty years. In forty years it will be £4; in sixty years, £8; in eighty years, £16; in one hundred years, £32; in one hundred and twenty years, £64; in one hundred and forty years, £128; and in one hundred and sixty years, £256. If a thing is worth what, under favourable circumstances, it costs to produce it, then this last-mentioned sum of £256 represents the value of an acre of land originally bought at £1, at the time pine timber will have come to maturity upon it, and this without including the charges of taxes on the land. These figures would seem to show that the pine-forests of the United States are

being, or have been, sold and consumed at a price very much below their actual value.

"In years past, vast quantities of pine timber in the north-west part of the United States have been stolen from the Government, and at the very time the latter was employing agents to guard it. In very many instances, after the timber has been stolen, innocent parties, supposing from the official maps that the land was timbered land, have purchased it from the United States at private entry, at £1.25 per acre. Interest on the purchase-money and taxes have, in the course of twenty years, made such land cost the owners from £3 to £4 per acre, and yet the land would not bring 50 cents per acre. Many a man has been kept poor paying taxes on such lands. Again, timber lands have been sold off in such large quantities, and so rapidly, as to glut the timber market.

"But a more important fact is, that no means have been taken to promote regrowth. Where hardwood timber is cut, there is always a chance for regrowth by the sprouts from the stumps and roots, but with pine and spruce it is otherwise; and where closely growing forests of pine and spruce are cleared without leaving seed-trees, the land may remain for ever a waste, growing every year more barren.

"In the report above referred to, it was shown that the practice in Sweden, when cutting pine timber, is to leave six or seven seed-trees to about each quarter of an acre. After five or six years the seed-trees may be cut."

Mr Budd of Iowa, who has grown trees largely, says:—

"A grove of 10 acres of white ash, thinned to 6

feet apart, containing 12,000 trees, at twelve years were 8 inches in diameter and 35 feet high,—the previous thinning paying all expenses of planting and cultivation. Ten feet of the bodies of these trees were worth, for making bent stuff, &c., 40 cents each, and the remaining top 10 cents,—making a total of 6000 dollars as the profits of 10 acres in twelve years, or a yearly profit of 50 dollars per acre for each year's growth. Mr Everett is said to have sold 23 acres of black walnut, of twenty-three years' growth, for 27,000 dollars, or 50 dollars per acre for each year's growth. By the way, it is well to remember that ash will grow where many trees will not." In this country, on the contrary, ash timber is most difficult to grow profitably to large size.

"But the great point noticeable is that the money is secured, or rather secures itself, without labour after the first ten years. Any plantation, men of experience say, in which the trees are 6 feet high, and the ground so shaded that weeds and grasses cannot grow, needs no more care till the time comes to thin it for posts."

CHAPTER X.

IMPORTANT LOCAL PLANTING.

No. 1.—Duke of Athole. The 'Journal of Forestry' for August 1887 gives the following account of Loch Ordie Plantation (the Duke of Athole's), planted 1815-1818:—

Outlay.

Purchase of ground, 2932 Scotch acres, twenty-five years' purchase, at 9d. per acre per annum, ...	£0	18	9	£2748	15	3
Fencing 11½ miles, at 5s. 6d. per rood of 6 yards, ...	0	6	2	902	11	2
Roads, drives, and bridges, at 7s. 6d. per rood, ...	0	8	0¼	1177	6	0
Plants, 6,377,100, at 4s. per 1200 (seedlings), ...	0	7	3	1062	17	0
Planting, ...	0	3	3	476	9	0
Miscellaneous, ...	0	2	6¾	375	13	6
Making good the failure of plants, . .	0	4	0	586	8	0
	£2	10	0	£7330	0	0

"A Scotch acre being about five-fourths of a statute acre, the above 2932 Scotch acres, at 50s. per acre, are equivalent to 3665 statute acres, at 40s. per acre. The above careful calculation of costs will be useful at the present date as a basis of similar calculations.

Mr M'Gregor, who has charge of the Duke of Athole's woods and forests, has furnished the following details, which will bring down the information as to costs to date :—

"We may presume from the above that seedlings cost the planter 4s. per 1200 in his private nurseries. Very little seed has been ripened in Scotland during the last two years, and the cost of the common conifers has arisen considerably in consequence. The usual price charged by nurserymen is 10s. or 12s. per 1000 for larch plants, two-years' seedlings and two years transplanted, and 8s. or 9s. if one year transplanted. The number required per acre is from 2500 to 3000. A man can plant 1000 or 1200 plants a-day, aided by a woman, girl, or boy. The expense of planting will therefore be about 9s. or 10s. per acre, instead of 2s. 7d., as in the above estimate, and the plants will cost 25s. or 30s., instead of about 5s. 10d.—increased afterwards to about 9s. in the process of 'making good.' Since 1847 the prices of labour have risen in the district under notice. Female labour has risen from 10d. a-day to 1s. 6d.; men who received from 1s. 6d. to 2s. a-day as wood labourers during several years since 1847, now receive from 14s. to 16s. a-week."

No. 2.—Report on Extensive Planting. By James Brown, jun., Craigmill, Stirling (Scottish Arboricultural Society's Transactions, 1871) :—

"*Auchtabhan Plantation.*—This plantation forms part of the extensive estate of Invercauld, belonging to Colonel James Ross Farquharson, and is situated in the county of Aberdeen.

"It was enclosed with a wire fence, which, from

the circumstances of the case, cost more than the generality of such fences for wood enclosures. This arose altogether from its being necessary to erect a fence of such a height as would prevent the inroads of deer. The extent of the enclosure, according to a plan and measurement made at the time, is about 980 acres. This includes about 50 acres of hill-top and rocky ground, which is unsuitable for planting, together with about 30 acres of natural grown birch.

"*Kinds and Ages of Plants used.*—During the first season's planting, the following were used: Scots pine, two-year seedlings, one year transplanted; larch, one-year seedlings, one year transplanted. It was found, however, that the Scots pine of this age did not succeed well. The deaths were very numerous indeed. This was owing to their being large plants—too large to suit a bare hillside. On a large proportion of the ground on which these were planted the heath was short, and their tops stood above it; consequently the wind, in sweeping along the face of the hill, got too much hold of them before they had established their roots in the ground, and the consequence was that, from the action of the wind, a hole was formed round the stem of a large number of plants, and the roots becoming exposed to the weather, they died.

"An interesting experiment to arboriculturists has been tried on this plantation with 1000 *Douglasii*. A few of these plants have been inserted in different exposures and elevations all over the grounds,—some in nice sheltered hollows and glens, where the soil is deep and comparatively rich, and others on bare and exposed situations, with very thin soil, at different heights and on different aspects. The plants were of the age, one-year seedlings, one year transplanted;

and as their height was only about 5 inches when put in, those on the exposed parts will have a fair chance of getting a firm hold of the ground before the wind can have much power to disturb them.

"The larch were planted at 15 feet apart, and the ground filled up with Scots pine to the average distance of from $3\frac{1}{2}$ to 4 feet over all.

"A portion of the plantation was planted in 1867, another portion in 1868, and the remainder we intend planting this autumn. The operations in each year were begun about the middle of October, and continued without many stoppages by the weather until about the end of April in the following year. I find, however, that for high-hill planting, the months of autumn are much preferable to any other, and I consequently endeavoured to get in as many plants as possible in the months of October, November, and December in each year.

"The weather during the time of planting was, generally speaking, very open and favourable. No frosts of any consequence were experienced; but sometimes, especially in the spring of 1868, we had very heavy falls of rain, which, however, did not interfere much with the planting, the land being mostly dry, with a firm herbage in many places. Indeed, as a whole, a more favourable time for planting moorland I have seldom experienced.

"*Cost of Formation of Plantation.*—A small portion of the ground is still to plant, but as it is intended to do this this autumn, the following statement embraces the expense estimated for the finishing of the whole plantation:—

Enclosing—		
For 8797 yards of wire fence, solid galvanised, half and half, of Nos. 6 and 8, ...		£109 14 10
Posts of larch, 2618, ...		59 0 0
Eight iron straining-pillars and workmen's tools, .		21 16 9
Herding off deer during erection of fence—planting being in progress, ...		15 15 0
Labour erecting fence, ...		36 9 2
Horse work in connection, ...		4 11 0
Killing hares and rabbits, ...		4 4 2
Expense of enclosing. . . .		£251 10 11
Draining, total cost, ...		25 3 0
Plants and planting—		
Scots pine, 2,034,000 of two-year one year, and one-year one year, at the average rate of 7s. per 1000, . .	£722 4 6	
Larch, 665,500, one-year and one year, at about 10s. 6d. per 1000, . .	357 12 0	
Abies Douglasii, 1000, 5 inches high, .	10 10 0	
Mats, packing, &c., ...	6 10 0	
Carriage of plants from railway station to plantation, ...	23 5 2	
Labour planting, ...	316 10 3	
Cost of plants and planting, ...		£1436 11 11
Total cost of forming plantation, ...		£1713 5 10

"We have now, therefore, a sum of £1713, 5s. 10d., as representing the total cost of the formation of a young plantation of 900 acres, situated in one of the highest lying districts of Great Britain. This gives us about £1, 18s. 1d. per acre, or as under:—

Enclosing, ...	£0 5 7
Draining, ...	0 0 6
Planting, ...	1 12 0
	£1 18 1"

Extract from Report of Highland and Agricultural Society, 1871, on Management of Plantations. By William Gilchrist, Castlemilk.

"No. 3. This is a mixed plantation, formed on the western boundary of the estate, and contains about 51 imperial acres or thereby. It was laid off about the middle of February 1862, and was intended for a fox covert. The main body of it is laid off in a quadrilateral form. A belt, 60 yards broad, extends northwards along the upper side of the adjoining park, and joins into a natural glen or hollow, containing about 3½ acres. The glen, belt, and main plantation are all included in the one measurement, having been all formed and planted at the same time and in the same manner; and besides, their connection is unbroken, the whole being enclosed with the one line of fences.

"Planting operations were begun in this plantation on the 17th of March, and finished on the 14th of April, the time occupied being only four weeks. However, it could have been better and cheaper done had the men employed been accustomed to the work. A great many of them were just beginning to be able to do a fair and reasonable day's work (and to do it right), when the planting was finished; and besides, a great many of them had not even been accustomed to outdoor work, numbers of them being unemployed factory hands from the neighbouring town.

"The following table will show the average growths of the different varieties for the five years after being planted:—

	1862.	1863.	1864.	1865.	1866.	Percentage of deaths at three years.
	Inches.	Inches.	Inches.	Inches.	Inches.	
Scots fir, ...	4	3	6	11	14	6
Larch, ...	6	6	9	13	18	3
Spruce, ...	2	3	5	9	10	5
Silver fir, ...	2	2	3	6	6	5
Austrian pine, . . .	2	2	6	7	11	10
Oak, ...	4	2	4	6	10	4
Ash, ...	D	estroy	ed.	6	10	75
Elm (English), . .	6	4	6	6	12	...
Horse-chestnut, . .	6	2	2	6	6	4
Lime, ...	4	5	5	8	12	3
Sycamore, ...	5	3	6	6	10	3
Black Italian poplar,	6	9	12	15	15	2
Huntingdon willow,	5	6	12	8	18	2

"From this table it will be seen that most of the hardwood plants made greater growths the first year than they did the second; no doubt this was owing to the plants being full of sap and vigour when they were removed from the nursery ground; but the situation being so unfavourable for their development, they put forth their young shoots strongly the first season, but the next season (owing to the want of nourishment the previous year), they had life but not much vigour.

"When this plantation gets up a little, it is intended in the future management of it to divide it into five portions—one of these to be thinned, the brushwood cut, and the drains cleaned every fifth year; also the hawthorns that were left as standards to be taken out as the trees grow up: of course, when the thorn-trees are taken out, a few Scots fir and spruce will require to be transplanted in their places to prevent blanks.

"The following is a detailed statement of the cost of formation and enclosing of this plantation:—

		£	s.	d.
85,000	larch, at 20s. per 1000, ...	£85	0	0
117,000	Scots fir, at 12s. per 1000, ...	70	4	0
27,000	spruce fir, at 16s. per 1000, ...	21	12	0
7,000	silver fir, at 40s. per 1000, ...	14	0	0
1,000	Austrian pine, at 30s. per 1000, . . .	1	10	0
1,000	oak, at 20s. per 1000, ...	1	0	0
4,000	ash, at 15s. per 1000, ...	3	0	0
500	elm, at 16s. per 1000, ...	0	8	0
300	sycamore, at 2s. per 100, ...	0	6	0
500	horse-chestnut, at 4s. per 100, ...	1	0	0
1,100	lime, at 10s. per 100, ...	5	10	0
1,100	poplars, black Italian, at 3s. per 100, . .	1	13	0
500	willows, Huntingdon, at 3s. per 100, . .	0	15	0
246,000				

Planting 51 acres, at 28s. 10d. per acre, .	£73	10	6			
Clearing the ground and cutting brushwood,	10	17	2			
Draining, ...	102	4	8			
Probable cost of making rides, ...	22	8	6			
				£209	0	10
Making up blanks at the end of three years—						
Plants and planting, ...	£8	16	6			
Cutting whins, briers, and bramble, . .	3	16	0			
				12	12	6
Fencing—						
715 yards young hedge, at 1s. 4d. per 18 feet, ...	£7	18	10			
900 yards cutting over, at 6½d., . . .	4	1	3			
748 yards half cutting over and fencing, .	9	7	0			
3465 yards of stob and rail fence, at 5d. per yard, ...	72	3	9			
				93	10	10
				£521	2	2

"From the foregoing statement it will be seen that the average cost per acre of this plantation (containing in all 51 imperial acres or thereby), for clearing the ground, draining, plants and planting, formation of rides, fencing, and making up of blanks at the end of three years, has been £10, 4s. 4½d. Certainly a very

high average, but larch plants were high priced; besides, the clearing of the ground and planting cannot be taken as a fair estimate of what that sort of work should cost, for, as before mentioned, most of the men were totally unaccustomed to the work."

Robert E. Brown, Wass, Yorkshire, in a Report to the Highland and Agricultural Society, says:—

"No. 4. *The mode of Planting adopted.*—All the plants used were put in the soil by the system of notching. One portion of the plantation was planted in 1857, another in 1858, and the other and remaining portion in the year following. The weather during the time the planting operations were going on was varied, as from the large extent of land to be planted the operation extended over the autumn and spring of each of the years referred to. There were generally sharp frosts in the mornings, which prevented the planting being done when this occurred. The workmen were, in these cases, put to the draining operations, and as soon as the soil was sufficiently soft, planting was proceeded with.

"*The kind of Trees planted.*—The trees planted were larch, Scots pine, and spruce. On the highest points of the plantation, where the soil was thin and the position exposed, Scots pine alone were planted at 3½ feet apart, or at the rate of 3500 per acre. On the lower portions, where there was a great depth of earth, and of better quality, Scots pine were inserted at 8 feet apart, and filled up with larch to 4 feet apart over all, or at the rate of 2700 per acre. Where the soil was peat, a mixture of spruce, fir, and Scots pine was used.

Expenses in the Formation of Plantation No. 4.

Fencing—			
1112 yards of four-barred paling, at 9¾d. per yard, .	£45	3	6
5685 yards turf dyke, with paling on top, at 5¾d. per yd.,	136	8	2
Drainage—			
18,128 yards drains, at 1½d. per yard, ...	113	6	1
Plants—			
Scots pine, 1,446,150, at 4s. 6d. per 1000, ...	325	7	8
Larch, 223,420, at 6s. per 1000, ...	67	0	6
Spruce 54,220, at 12s. per 1000, ...	32	10	6
1,723,790			
Planting—			
Workmen's wages planting the whole, ...	254	3	4
Cartage of plants, ...	15	1	6
	£990	5	3

Cost of Management and General Maintenance from the year of planting 1859 *to* 1867 (*eight years*).

Scouring and cleaning drains, ...	£8	15	2
General repairs of fence, looking over enclosure, and clearing snow from turf fence, &c., ...	76	4	10
	£85	0	0

"The cost of the plants may seem very low, but they did not cost the proprietor any more, as they were reared in the home nursery on the estate.

"By the foregoing table of expenditure is brought out the cost of the different works at the following rates per acre:—

Fencing, ...	6s. 7d.	per acre.	
Draining, ...	4s. 1½d.	"	
Cost of plants, . . .	15s. 7½d.	"	
Planting, ...	9s. 2½d.	"	
Maintenance, . . .	0s. 4½d.	"	per annum.

"The plantation was in a very healthy and satis-

factory condition in October 1867, excepting on the very high, dry, exposed parts, where the trees have not made much progress. On the lower and middle ground the larches are now, on the average, 5 feet high, several having grown as high as 9 feet. The Scots pine will average 2 feet high. Both larch, Scots pine, and spruce have made the most progress on a light soil with a gravelly bottom. The expenses for the last five years, in the general maintenance of the plantation, has amounted to £85, or nearly at the rate of 4½d. per acre annually. This expenditure has been for fencing, clearing drains, and looking over the plantation, but does not include foresters' wages, or the value of the timber used in repairing the fence."

No. 5 is what is generally termed a mixed fir plantation, composed of Scots pine, larch, and a small portion of Norway spruce in Strathspey. The plantation comprises about 550 acres, planted between October 1857 and January 1861, both inclusive. It is fully and freely exposed on every side, being higher than the surrounding ground; and with the exception of one ravine, the trees are all fully exposed to the elements. The climate is generally considered cold, but the air is dry and bracing. The soil is of various qualities, but generally of a moorish and gravelly nature. The prevailing rock is granite, which in some parts is near the surface of the ground, and occasionally above it. Moss also prevails in some places; and there are also patches of sandy loam.

Planting was commenced in October 1857, and continued when weather permitted till the following May. The work was again resumed in October 1858,

and continued until the end of April 1859. The latter month, and also May, proved very dry and scorching, which was very hurtful to the spring-planted trees, but had little or no bad effects upon those planted during the preceding autumn. *So visible is this difference of growth, that it can be observed fully a mile distant.* The difference of advancement of growth is indeed so great as to indicate a lapse of *fully three years* between the *autumn* and *spring* planted trees; and what is still further remarkable is, that there were scarcely any deaths of the trees during the season among either autumn or spring planted, neither was there any making up required, and yet the disparity of growth is as above described. One reason why the distant appearance is so striking is in consequence of the side where the autumn planting ceased being almost an entire straight line, running at right angles to the slope of the hill, which shows exactly where *autumn* planting was left off and where *spring* planting began. The trees planted in spring were of the same stock as those planted in autumn—the workmen were also the same; and indeed, save the season of the year, all things affecting the growth of the plants seemed alike. The ground upon which the above disparity of growth took place was sandy moorland, upon which the heather had been burnt three years previous to planting, to induce young herbage to grow up. The comparative bareness of herbage, the dry nature of the soil, and the full southern exposure, all combined in producing the results set forth; but why corresponding bad effects did not occur with the autumn-planted trees does not clearly appear, but from which circumstances we may

profitably learn that *autumn planting* is preferable to that of *spring*, especially when the succeeding season is hot and dry.

The plants used in planting this enclosure were mostly one-year seedlings, two years' transplanted Scots pine and larch; or to be more explicit, one-year seedlings, one year bedded, and one year transplanted in the home nursery. The drained ground was planted with a mixture of Norway spruce and Scots pine. The whole of the plants, except about 450,000, were planted one year in a local nursery with a view to acclimatising them. The benefits supposed to arise from acclimatising are, however, much less important and real than many persons are prepared to admit. This is very obvious from the following circumstance: The 450,000 plants alluded to were not acclimatised, but brought directly from Edinburgh and planted at once into the enclosure. They received the same treatment as regards planting, soil, situation, &c., and have maintained throughout their growth a health and vigour equal in all respects to those acclimatised. They differed, however, from the other plants in one respect—viz., in their being one year younger. They were one-year seedlings, one year bedded only, and not, as the others, transplanted.

The one-year seedling, one year bedded plants, were the first planted in the enclosure; and as it was anticipated that a considerable portion of them would perish, they were planted only about $3\frac{1}{2}$ feet apart. Others, also planted the same season, were planted at similar distances. It was soon seen, however, that no deaths occurred as expected, and the distance apart was by degrees extended, till, finally, the plants were

put in at $4\frac{1}{2}$ feet apart, instead of $3\frac{1}{2}$ feet as at the commencement.

The manner of planting adopted being to many persons new, deserves special notice. The common half-worn garden spade was used, and the planting done by notching and slitting, or ⊥ and L, as best suited the roots of the plants or the nature of the soil. A steady good workman was put in front to take the lead forwards, and another, similarly qualified, to take the lead backwards.

The first man put in his plants 7 feet apart, or 9 feet, as the case may be, and each advancing planter put his in $3\frac{1}{2}$ feet or $4\frac{1}{2}$ feet back from the last, and also 7 feet or 9 feet apart the other way. By this arrangement there can be no crowding of the planters upon each other, and every man must do the same amount of planting; and if any are imperfectly done, the foreman can at once discover who it is that is doing his work improperly.

From twelve to sixteen spadesmen composed a company, with an equal number of boys and women; and over these a foreman was placed, who did not himself work, but travelled backwards and forwards amongst the people, sometimes in front and sometimes in rear, so that no plant might be carelessly planted without being detected and put right.

The following diagram will better illustrate the method of arranging the planters than words can do.

The company indicated by the diagram is six in number, each figure representing a man; and by following No. 4 or any other one, it will be seen what course and part he takes.

1 1 1 1 1 1 1 1 1 1 1 1 1

2 2 2 2 2 2 2 2 2 2 2 2

3 3 3 3 3 3 3 3 3 3 3 3 1

4 4 4 4 4 4 4 4 4 4 4 2

5 5 5 5 5 5 5 5 5 5 5 3 1

6 6 6 6 6 6 6 6 6 6 4 2

6 6 6 6 6 6 6 6 6 6 5 3 1

5 5 5 5 5 5 5 5 5 5 4 2

4 4 4 4 4 4 4 4 4 4 4 3 1

3 3 3 3 3 3 3 3 3 3 3 2

2 2 2 2 2 2 2 2 2 2 2 2 1

1 1 1 1 1 1 1 1 1 1 1 1

Return, 1 1 1 1 1 1 1 1

Planting forest-trees in straight lines is objectionable, and it might be inferred from the diagram that an infringement of this rule is made in that respect. This, however, is found in practice not to be the case; as when a straight-sided fence would lead to this form of planting, the straight line is broken by advancing the central or any other part beyond the straight line. When the men carried and put in their own plants they planted between 700 and 800 daily; while, with the aid of a woman or boy, they planted from 1000 to 1100 per day and upwards. Besides those putting in the plants, there were others, sometimes two or more of the strongest of the women, employed carrying the plants from the plant-bed to the planters in sheets of strong canvas 6 feet square. The carriers, as they were termed, had 2d. per day more wages than those employed planting, in consequence of the

work being heavier and requiring stronger persons to do it.

When the ground was bare of herbage a notch was simply made, and the plant put into the ground an inch deeper than it stood in the nursery ground. On the other hand, when the herbage was rank and the turf matted, the spade was employed to clear or pare it off. This entailed about one-fourth additional expense, and in some places nearly a third; but the advantages arising from the practice warranted the additional expense, as thereby the roots of the plants were at once admitted to the sand or gravel underneath without burying the stem of the plant too deeply, which always proves hurtful, and often fatal. When the paring system was practised one woman put in plants to two men, effecting a saving of 5d. per day, which was accredited to the paring system, thus so far reducing the expense attending it.

Not more than 2 per cent of deaths occurred amongst the Scots pine during the first two years after planting, after which period they are considered beyond risk; while about 10 per cent of larches perished during the same period, and still continue to decay, though not to such an extent. The cause of failure in the larch was evidently either coldness or hardness of soil, as the parts where it degenerated were either cold moss or hard pan.

The following is a statement of the expenditure originally incurred in making the enclosure:—

Fences—			
5680 yards turf dyke at 4½d. per yard,	£106	10	0
5680 yards one-bar paling and posts at 1d. per yard, ...	23	13	4
Carry forward, . .	£130	3	4

Brought forward, . .	£130 3 4	
1112 yards four-bar post and rail fence at 7½d. per yard, . . .	34 15 0	
		£164 18 4
Drains—		
900 chains open drains at 2s. 9d. per chain, . .		123 15 0
Plants—		
1,100,000 one-year and two-year Scots pine at 6s. per 1000, . . .	£330 0 0	
450,000 one-year and two-year Scots pine at 4s. per 1000, . . .	90 0 0	
220,000 one-year and two-year larch at 8s. per 1000, ...	88 0 0	
25,000 one-year and two-year Norway spruce, at 10s. per 1000, .	12 10 0	
		520 10 0
Planting 1,795,000 plants, at 3s. 9d. per 1000, . .		336 11 3
Carriage of ditto, 3d. per 1000, ...		22 8 9
Incidental expenses, ...		9 16 8
Total, . . .		£1178 0 0

£1178 ÷ 550 acres = £2, 2s. 10d. net cost per acre; about £20 sterling cost of maintaining per annum.

No. 6 is a plantation also in Strathspey, comprising about 1000 acres, planted with Scots pine and larch, and a small quantity of Norway spruce in mossy parts. It is situated between a distance of one and two miles from a station of the Highland Railway—hence prospectively more valuable on that account than No. 5, which is at least six miles distant from rail. The altitude of this enclosure is between 800 and 1600 feet. It is freely and openly exposed on all sides, and being higher than the surrounding ground, has no shelter from any point. The climate is cold and dry; but owing to the dry hard nature of the soil, snow, in its season, melts sooner here than on many other surrounding hills. The surface of the

ground is chiefly covered with heather (*Erica*) and cranberry (*Oxycoccus macrocarpus*), and a small portion of it with broom (*Spartium*).

The principal object in forming this plantation was with a view to pecuniary profit. In consequence of the rugged and rocky surface of the ground, combined with the coldness of the climate, it could never be turned to profitable account for tillage; nor would it, in all probability, have ever exceeded its present value as an outrun for the adjoining tenant's sheep, or as a shooting for grouse and other game. The value of the ground for sheep pasture was variously estimated at from 1s. to 2s. per acre. While the tenants occupied it, they maintained that it was not worth 1s. per acre; but when about to lose it for planting, they offered 2s. per acre for it. Hence it may be assumed that it was worth the latter sum.

Enclosing.—The plantation was enclosed with a turf dyke and rail on top on one side, and a four-bar post and rail mortised paling on the other.

The quality of the soil is generally a light sandy moss, but varies in depth and quality. There are also a few deep mossy parts, and also some where sandy clay prevails.

Before commencing operations of planting, several plant-beds were duly prepared, each sufficiently large to contain three or four loads of plants, lined out in rows. The plants, when taken forward in carts, were all loosed out of the bundles, and as carefully and neatly "sheughed" into the ground as if they were intended to stand for several months. In preparing the ground, the stones were all picked out and the soil well pulverised, so as to adhere to and fall closely in about the necks of the plants on being *sheughed* in,

which prevents frost or drying winds from injuring them.

Planting.—The work of planting was commenced in April 1859, and carried on during the planting season, when weather permitted, till finished in December 1862, being four seasons in planting.

The work was performed by a great number of men, women, and boys, under one or more experienced foremen, and all upon day-wages. Each foreman had from twelve to sixteen spadesmen under him, with a corresponding number of women or boys to carry and put in the plants, the same as already explained, page 85.

The whole ground was planted to a general distance of a little over 4 feet apart, in the proportions of about one-third larch to two-thirds Scots pine, with a few spruces in the mossy ground.

The following is a statement of the whole cost of enclosing plants, planting, &c. :—

4 gates at 12s. each, ...	£2	8	0
6160 yards turf dyke at 4d. per yard, .	102	13	4
6160 " 1-bar paling on dyke top at 1d. per yard, ...	25	13	4
2000 yards 4-bar post and rail paling at 7½d. per yard, ...	62	10	0
60 chains open drains, at 2s. 8d. a chain, .	8	0	0
214½ " " at 2s. 3d. a chain, .	24	2	7½
1,778,000 Scots pine, at 5s. 2d. per 1000, .	459	6	4
900,000 larch, at 10s. 8d. per 1000, . .	480	0	0
22,000 Norway spruce, at 10s. per 1000, .	11	0	0
Planting 2,700,000 plants, at 3s. per 1000, .	405	0	0
Cartage of ditto, ...	32	0	0
	£1612	13	7½

Or £1612, 13s. 7½d. ÷ 1000 = £1, 12s. 3d. per acre.

The plantation is in general growing well, having grown beyond reach of black-game, which often pick out the top buds to a serious extent for a few years after planting. On examining the plants about the months of March and April, it was very common to find from thirty to forty per cent of the Scots pine with their top buds picked out; and, contrary to general opinion, the destruction was always greater in mild open weather than in storms. As soon, however, as the plants attain from three to four feet in height, the injury complained of ceases.

The writer made a minute annual examination of the whole plantation for several years, and found the following the results of the top growth:—

	Inches.
First year after planting,	$1\frac{1}{2}$
800 best trees per acre,	2
Second year after planting,	$3\frac{1}{4}$
800 best trees per acre,	$4\frac{1}{2}$
Third year after planting,	$3\frac{1}{2}$
800 best trees per acre,	$5\frac{1}{2}$
Fourth year after planting,	$3\frac{3}{4}$
800 best trees per acre,	6
Fifth year after planting,	$4\frac{1}{4}$
800 best trees per acre,	$6\frac{1}{2}$
Sixth year after planting,	$5\frac{3}{4}$
800 best trees per acre,	$7\frac{1}{2}$
Seventh year after planting,	6
800 best trees per acre,	9
Eighth year after planting,	6
800 best trees per acre,	10
Ninth year after planting,	$6\frac{1}{4}$
800 best trees per acre,	$10\frac{1}{2}$
Tenth year after planting,	$6\frac{1}{4}$
800 best trees per acre,	10

The average height of the trees at ten years old is 3 feet $10\frac{1}{2}$ inches. The height of 800 of the best trees per acre is, at ten years, 5 feet 11 inches. There

are also some larch-trees in the plantation fully 12 feet, and Scots pine over 8 feet high.

Reckoning the top growth of 800 of the best trees at one farthing per lineal foot, the annual increase of value per acre would stand thus:—

First year, ...	£0	2	3
Second year, ...	0	5	0
Third year, ...	0	7	9½
Fourth year, ...	0	11	0
Fifth year, ...	0	13	6
Sixth year, ...	0	14	0
Seventh year, ...	0	16	0
Eighth year, ...	0	18	0
Ninth year, ...	1	0	3¼
Tenth year, ...	1	0	3¼

The annual increase of wood, though indicated by money, is not the true market value, seeing that a tree requires to be about 3½ inches diameter at 6 feet from the ground before it is considered of market value for pit-props; and after that period (or rather point of growth), every foot in length, which is understood to be one foot of prop-wood added to each tree, represents true money value, which in larch is about one farthing, and in Scots pine one-eighth of a penny, to the proprietor. The pine-leaf caterpillar has shown itself in several parts of this plantation, but its depredations have been as yet unimportant, being in each case confined to two or three trees, which, though stripped of nearly all their leaves, yet put forth their buds anew next season, and though much weakened by the loss of foliage, yet always recover. This is one of the most promising plantations in the north of Scotland, and one that is likely to pay the proprietor handsomely. In addition to the actual money returns, other and very important advantages are

likely to arise from this plantation—such as shelter to the surrounding arable land, the severity of the climate modified, labour in the district produced, the amenity of the property vastly enhanced, and the country generally greatly benefited and improved.

It is situated at an altitude of between 800 and 1000 feet.

No. 7 was begun planting December 9, 1862, and finished April 19, 1864. It contains about 450 acres, 50 of which is deep flow moss, and not very well adapted for the growth of trees; but all the other parts are very favourable, and likely to produce good profitable timber. None of the ground is flat, neither is it steep or rugged, but of a gently undulating nature, where trees generally grow well. The soil is of various qualities and description, but may be best described as sandy moorland, with a subsoil of granite rock and gravel. The herbage is much the same as those of Nos. 5 and 6—heathy moorland; nor does it in any important degree differ from them. The ground, except where the moss prevailed, and a few patches rendered wet by the discharge of springs, required no drainage.

The ground, previous to commencing operations, was closely and minutely examined both in the active and passive soils, and descriptive notes of it taken at some length, which were subsequently of no small value when the work of planting was going on. The general line of the fence being resolved upon after protracted examination of the ground, it was then staked off with poles about 5 feet long, one of which was put down at each place where a straining-post was to stand, and a number marked upon it with a pencil.

At this stage the proprietor had to satisfy himself fully as to the position of the fence, &c. The ground was next measured, and a rough plan of it made to a scale one-eighth of an inch to the chain, showing the extent of moss ground—parts requiring drainage—those suitable for larch, spruce, pine, &c. This plan, though neither finely got up nor finished, was yet found of great advantage in many ways.

Fencing.—The fence consists of 6747 yards of wire fence, 488 yards four-bar post and rail common paling, and 154 yards of turf dyke with a two-bar paling on top. The dyke was not built for the enclosure, it being a field fence, but now a field and plantation fence combined.

The whole of the wood (both rails and posts) was of superior quality of native Scots pine, which lasts equally well with the best quality of larch.

The straining-posts were 7½ feet long, 7½ by 7½ inches square, and put into the ground fully 3 feet, and at distances apart varying from 50 to 100 yards, or at an average distance of 75 yards. Each post was secured by means of underground braces, each 3½ feet long, and 6 by 3 inches. The intermediate posts were 6 feet long, 5½ by 2⅓ inches, and sharped for driving into the ground at 6 feet apart; but this particular distance was not strictly adhered to, in consequence of large boulder-stones interfering both below and above the surface. A number of braces were also required for sustaining the pressure upon the intermediate posts at curves in the fence, which were from 5 to 6 feet long, 3½ by 1¼ inch. The wire used was No. 4 for the two uppermost, No. 5 for the two middle, and No. 6 for the two lower. The staples were machine-made, and have this advan-

tage over hand-made ones, that they take a better hold, and are less liable to split the wood.

The following is a detailed cost of the fence :—

	£	s.	d.
100 straining-posts, at 2s., ...	£10	0	0
3792 intermediate posts, at 3½d., . .	55	6	0
330 underground braces to strainers, at 3½d., ...	4	16	3
167 braces for small posts, at 2½d., . .	1	14	9½
6747 yards (six wires deep), 160 gross wire staples, . } including, at 4½d. } .	126	10	1½
Nails for braces, &c., &c., ...	0	16	0
One contract for putting on 3107 yards wire,	12	18	11
One do. for putting on 3640 yards wire, .	12	0	2
Men's time on day's wages erecting wood-work of fence, ...	30	0	0
	£254	2	3

£254, 2s. 3d. ÷ 6747 yards = 9d. per yard nearly which the fence cost, and is both substantial and looks well.

No. 8 is a general mixed plantation in the county of Roxburgh, of which the following are particulars :—

It is a mixture of hardwoods, pine, and fir, planted in the spring of 1859. It is a long narrow belt, formed partly to shelter the adjoining land and form a game covert, to beautify the country, and partly with a view to profit. The plantation is about 1100 yards in length, and varies in width from 60 to 100 yards, comprising an area of about 20 acres. It is situated at an altitude between 400 and 600 feet, and fully exposed on every side, but more so to the north-west. The soil is in general a stiff cold clay, resting on whinstone rock, and a retentive tilly sub-soil, cold and wet.

From the wet and cold nature of the ground, besides other reasons, it was thought advisable not to adopt pits, the tendency of which is to collect and retain

water, which is highly injurious to plants. Instead of pitting the ground, another and better plan was adopted—viz., to pare off a thin turf from the surface, and by means of a peculiar footpick made for the purpose, termed the bore-bill or forester's footpick (see fig. 1, p. 10), the ground was well broken and rendered loose and open. This system is at least two-thirds cheaper, and the results otherwise much better than by pitting.

The hardwoods were planted at a general distance apart of about 17 feet, each sort allotted to the soil most suitable for it. Next to planting the hardwoods, the ground was gone over with silver firs, and planted in a way similar to the hardwoods, at a general distance of about 24 feet apart. Norway spruce was also planted in some soft mossy parts, about 10 feet apart. A few (300) *pinaster* were also planted promiscuously as a trial upon the driest and most exposed parts. Scots pine was planted at the rate of 750 to the acre or thereby, and larches at the rate of 1250 per acre—not regularly all over, but as much as possible to suit the soil. Undernoted is a statement of the whole expense:—

Fencing—		
531 larch posts, at 5d., ...	£11 1 3	
13 iron straining-pillars and stones, at 10s., ...	6 10 0	
Labourers' wages driving posts, &c., . .	5 8 6	
Contract for erecting 1062 yards wire fencing, at 6d., ...	26 11 0	
		£49 10 9
Drainage—		
1500 yards surface drains, at 1d., ...		6 5 0
Plants—		
1000 ash plants, 3 feet, at 23s. per 1000,	£1 3 0	
Carry forward, . . .	£1 3 0	£55 15 9

Brought forward,	£1	3	0	£55	15	9
1000 oak plants, 3 feet, at 26s. per 1000,	1	6	0			
1000 black Italian poplar, at 60s. "	3	0	0			
1500 silver firs, at 70s. "	5	5	0			
300 pinaster ditto, at 60s. "	0	18	0			
8000 Norway spruce, at 20s. "	8	0	0			
15,000 Scots pine, at 12s. "	9	0	0			
25,000 larch, at 18s. "	22	10	0			
				51	2	0
Expense of boring and planting the above,				13	4	0
				£120	1	9

£120, 1s. 9d. ÷ 20 acres = £6, 0s. 1d. per acre nearly.

No. 9. The following statement appeared in the 'Journal of Forestry,' November 1882:—

"It is now about forty years since I began to plant, and with the exception of the year 1846, I have planted every season more or less since then. During that time I have contracted for and had the charge of planting about 9000 acres, principally in Aberdeenshire, and all this has been done with the "hand-iron."[1] The number of plants used has been from 3000 to 3500 per acre, so that that extent of ground has required about thirty millions of plants, the sixth part of which, or five millions, have been planted with my own hand. During the first twenty years the plants used were all two-year-old seedlings, and the cost of planting, including plants and carriage of plants, was from 12s. to 14s. per acre. The lowest rate at which I ever planted was 10s. per acre, and that was for about 200 acres on the hill of H——, in the parish of L——. This plantation, which is now in a very thriving state, was planted with two-

[1] For a description of the "hand-iron," see 'Grigor's Arboriculture,' p. 54.

year seedlings, and required no upmaking. The hill of B——, in the parish of O—— M——, containing 133 acres, was planted with two-year seedling Scots fir and larch for 13s. per acre,—the whole of the planting being done by four men and myself in three weeks and three days. This is now a healthy and valuable plantation.

"During the last twenty years I have used a good many transplanted plants—*i.e.*, two-year seedlings, one-year transplanted Scots fir—especially where the herbage was rank,—consequently, owing to the increased cost of plants and the rise in workmen's wages, the contract price has greatly risen, and has ranged from 20s. to 30s. per acre; and in a few cases, such as at R—— W——, in the parish of A——, planted in 1876-77, the price has been, owing to the size of plants and quality of ground, as high as 42s. per acre. Between 1865 and 1870, the hill of C——, containing 450 acres, was planted with two-thirds Scots fir and one-third larch for 22s. 6d. per acre; and in 1871-72 the hill of M——, in the parish of R——, was planted for 25s. per acre. The extensive plantations on the estate of C—— F—— were done about the same price; while those on the estate of G—— M—— in Aberdeenshire, and on the estate of T—— in Kincardineshire, have ranged from 25s. to 30s.—the latter price having been got for planting ground that had previously grown a crop of Scots fir, and where there was a risk of damage being done by ground game. In most cases I have undertaken to make good all failures that occur during the first three years, except such as are caused by ground game, fire, or the inroads of cattle and sheep."

These statements may seem startling to many of

your readers, but they are not singular, as in 'Grigor's Arboriculture,' pages 56 and 58, examples of contract planting are given at 10s. and 10s. 6d. per Scotch acre in the year 1830; while at page 62 other examples are given at 16s. and 19s. per acre,—and it is important to note that the same system is still practised in the north, though at advanced rates. Of course, it must be understood that this mode of planting is only suited for hill-ground, where the heather is short and the soil free and open. The person whose experience I have quoted above states: "The greatest difficulties I have had to contend with are where the ground has a close grassy surface." It must also be understood that the prices given above are only for plants and planting, and to this must be added the cost of enclosing and drainage where necessary. Still, with these items added, the cost of planting ordinary hill-ground will not exceed from 30s. to 40s. per acre, or say 500 acres planted and enclosed for less than £1000. Surely that ought to be an inducement to proprietors in the north of Scotland to plant suitable portions of their hill-ground.

[TABLE.

GENERAL REFERENCE TABLE.

Number of Plantation.	Name of Plantation, as per Estate Plan.	Date of Planting.	Contents of each Plantation.			Date of Report.	Average Number of each Species of Tree per Acre.									Total Average Number per Acre.	Total Value of each Plantation.			Average Rate of Annual Growth at Date per Acre.		Value of Annual Growth per Acre.		Transferable Value per Acre at Date.				Prospective Value per Acre at Date.			
No.	Name.	Year.	Ac.	ro.	po.	Year.	Oak.	Ash.	Elm.	Beech.	Sycamore.	Scots Fir.	Larch.	Spruce and Silver Fir.	Various.	Trees.	£	s.	d.	Year.	Growth in feet.	s.	d.	Year.	£	s.	d.	Year.	£	s.	d.
1	A	1826	65	1	16	1869	..	..	..	..	..	266	12	4	8	290	1044	0	0	1869	192 lineal	17	0	1869	16	0	0	1886	26	0	0
2	B	1844	40	3	32	1870	..	..	..	..	..	345	50	5	..	400	326	0	0	1870	300 "	12	6	1870	8	0	0	1904	29	5	0
3	C	1835	37	0	2	1868	4	42	2	..	..	126	41	20	15	250	563	10	0	1870	63 cubic	25	0	1870	15	10	0	1895	43	0	0
4	D	1843	72	0	26	1870	..	..	..	..	..	338	20	2	..	360	745	0	0	1870	300 lineal	12	6	1870	10	7	0	1903	23	0	0
5	E	1837	14	1	7	1868	..	..	..	..	..	282	41	2	5	330	128	5	0	1870	247 "	27	0	1870	9	0	0	1897	56	11	0
6	F	1837	28	0	0	1870	..	..	..	..	..	251	80	..	25	360	308	0	0	1870	270 "	11	0	1870	11	0	0	1897	28	7	0
7	G	1847	6	1	12	1870	..	..	..	..	..	149	236	3	2	390	62	5	0	1870	292 "	12	2	1870	10	0	0	1907	32	10	2
8	H	1860	276	1	17	1870	..	..	..	..	..	1249	496	5	..	1750	2210	0	0	1870	656¼ "	10	0	1870	8	0	0	1920	30	0	0
9	I	1810	31	3	26	1870	2	3	..	1	..	64	29	..	16	115	125	0	0	1870	..	..		1870	3	18	8	1870	3	18	8
10	J	1858	36	1	37	1870	..	..	..	2	..	270	317	10	1	600	326	5	0	1870	500 "	20	0	1870	9	0	0	1838	35	0	0
11	K	1847	333	1	15	1870	..	..	..	..	..	256	74	..	..	330	2374	8	1	1870	165 "	7	6	1870	7	2	6	1907	18	0	0
12	L	1838	7	1	8	1870	..	..	..	..	..	561	56	63	..	680	82	3	4	1870	85 "	7	1	1870	11	6	8	1888	17	10	2
13	M	1839	7	2	0	1870	10	94	101	..	..	..	..	92	3	300	167	11	10	1870	50 cubic	25	0	1870	22	6	11	1899	43	5	0
14	N	1861	2	2	4	1870	58	58	58	..	..	..	426	80	..	680	30	0	0	1870	850 lineal	17	8	1870	12	0	0	1921	40	0	0
15	O	1839	2	3	2	1870	..	127	87	..	..	48	54	31	13	360	56	16	8	1870	28 cubic	23	4	1870	20	13	4	1899	40	0	0
16	P	1856	2	2	6	1870	2	4	4	..	..	..	868	..	1	880	22	10	0	1870	700 lineal	28	4	1870	9	0	0	1916	35	0	0
17	Q	1857	7	0	26	1870	1	..	..	..	..	..	1198	1	..	1200	65	0	0	1870	600 "	25	0	1870	12	0	0	1917	50	0	0
18	R	1852	4	0	12	1870	..	..	..	..	..	457	160	23	..	640	33	0	0	1870	180 "	7	6	1870	11	10	0	1906	21	12	0
19	S	1846	13	3	33	1870	..	..	..	..	..	481	258	31	..	700	224	0	0	1870	700 "	20	0	1870	19	10	0	1906	40	0	0
20	T	Old	8	3	8	1870	12	2	..	16	2	1	3	..	6	42	260	10	0	1870	..	15	0	1870	24	0	0	1870	24	0	0
21	U	Old	5	1	30	1870	6	11	10	32	..	11	7	..	6	83	185	6	0	1870	..	27	8	1870	37	1	3	1870	37	1	3
22	V	1836	6	0	15	1868	..	36	124	..	96	..	14	..	30	300	98	0	0	1868	20 cubic	10	0	1869	16	0	0	1896	30	0	0
23	W	Old	8	0	29	1867	1	2	1	38	..	..	..	..	4	46	352	14	0	1867	..	30	0	1867	49	0	0	1867	49	0	0
24	X	Old	24	3	31	1868	..	1	1	2	..	107	5	..	21	137	985	14	6	1868	..	25	0	1868	40	0	0	1868	40	0	0

The vertical or top growth of a tree being found, an acre or forest can very easily be ascertained by the eye of the practical forester, and reduced to authentic figures by a very simple process of arithmetic. And it would be well if all other figures relating to forestry and tree culture were as much to be relied upon.

The tree, however, not only increases in length, but also in thickness; and while ninety-nine persons out of every hundred will tell at sight how much a tree is annually making in height, probably not over one in a hundred will be able to say (even approximately) how much the tree is increasing in thickness or girth. The following is our method of doing it, and practice alone perfects the process: Take a tree 48 feet high, equal to 576 inches, and if a pine or fir, and proportionally grown, it will be 48 inches girth at base, or 24 inches at the centre; therefore multiply the length, 576, by the girth, 24, and 13,824 superficial inches are the result. Now, if the layer of wood were an inch thick, the figures 13,824 would just remain as they are; but if, instead of the zone or layer being 1 inch thick, it is only one-eighth of an inch—which I consider the proper thickness for the tree to make if proportionally and well grown — therefore, instead of multiplying, we require to divide, and according as the zone or layer is thick or thin, so will the quotient be.

Assuming, therefore, that such a tree is making woody layers one-eighth thick, the tree is thereby making 1 cubic foot of timber annually. Taking the same size of tree, however, and making not one-eighth thickness of layer of wood, but only one-twelfth yearly—therefore, instead of making 1 cubic foot, it is making

only 1152 cubic inches; or if making only one-sixteenth instead of a twelfth, the result is 864 cubic inches, or half a foot. Therefore the tree will only contain one-half the quantity of timber at a given age, when making one-sixteenth of layer, that it would if making one-eighth. It must then appear that, unless a tree is allowed conditions under which it can grow sufficiently fast, it will die of disease or old age before it attains proper timber size.

CHAPTER XI.

PLANTING UNDERWOOD AND GAME COVERT.

As soon as there is sufficient moisture in the ground, autumn planting should be proceeded with, and no time should be lost after the middle of September for planting in general, and especially game covert, of evergreens—as holly, yews, box, privet, laurel, rhododendrons, &c.

When a plantation has ceased to grow game covert properly, which all plantations and forests do in course of time, if grown in masses, and the trees for profitable purposes, they must either be renewed in order to maintain their efficiency, or new ground taken for the purpose. Failure is the general result of planting amongst old trees, notwithstanding that the space is quite open and clear of branches overhead. It is not enough, on entering a plantation and finding an open space, to conclude therefrom that trees or shrubs planted in it will grow. It is quite necessary that the space be clear and open, but that is not sufficient to ensure the success of newly put in plants. The roots of the surrounding trees, though distant, have invariably taken full possession of the open area, and thoroughly interwoven and exhausted it of every particle of plant-food within reach.

The only two ways in which I have ever attained true success in making up blanks and renewing old plantations, apart from cutting down and clearing the whole crop, is either by grubbing out all the trees and roots within the area to the depth of 18 inches, or to cover the whole surface of the ground from 12 to 18 inches deep, less or more, with new and fresh soil from any convenient place; and as the surface-soiling proceeds, the old turf should be roughly broken and mixed with it, but always kept underneath. Where a new road is in course of formation, the surface soil taken off is suitable for the purpose. When arable fields have in places unnecessarily deep deposits of moss, sand, or loam, such may at times be reduced, without detriment to the land, and suit the purpose well. In other cases the requirements are met by carting the surface excavations of open drains, removing old turf dykes, &c. Indeed, almost any change of soil will do; but the distance of cartage is a very important consideration.

When surface-soiling is impracticable, and trenching of some sort is resorted to, the ground should, if possible, be allowed to lie one season unplanted.

What applies to group-planting applies equally to that of planting single trees or shrubs. It is not sufficient preparation of the soil in old plantations merely to trench it up and make a pit large or small. The old soil should in all cases be taken out, and either wholly or partly substituted by other and better soil, or be improved by fallowing, mixing with leaf-mould or other compost—always excepting lime—when pines or rhododendrons are to be planted.

The principal reason for maintaining old woods near the mansion in this way is, that there may never at

any one time be so much wood cut down as to cause a serious blank or opening, so as to detract from its beauty and amenity, and that, without unduly extending the area of the woodlands, sufficient game covert may be uniformly maintained.

In isolated places the soil is found sufficiently rich to admit of replanting without any artificial aid beyond drying it, which is necessary in all cases. Such places are, however, very rare, and would grow still better by breaking up and removing the old roots; and for the better growth of hardwoods, such as oak, elm, and ash, the addition of a little lime is sometimes commendable.

Next to preparing the soil and putting it into proper condition, is that of having the plants in good order for planting. For this purpose it is essential that they be either grown in a home nursery or in a public nursery near at hand. This is necessary, in order that the plants may be safely removed at such times and in such a manner as suits the circumstance of each case; and it rarely gives a plant full justice to convey it from a distance, often also from a rich soil and sheltered situation, and place it under conditions quite of an adverse and opposite nature.

The shrub plants most preferable for this and other districts where a strong breeze prevails, and rabbits have to be contended with, are, first, the common variety of the rhododendron, the *Rhamnus frangula*, *Daphne laureola*, the buckthorn, tree-box, and the common elder and American hag. The two latter to be occasionally slashed and laid down half cut through, in which position game are fond of going underneath for shade, shelter, and security.

CHAPTER XII.

CITY AND ROADSIDE PLANTING.

EXTRACT from the 'Journal of Forestry,' November 1884:—

"*Tree-planting in Edinburgh.*—This topic has recently occupied the correspondence columns of the 'Scotsman,' and we recur to it the more readily, as the subject was originally started in these pages some years ago. Some progress has been made. In one or two thoroughfares young seedlings, carefully guarded, are struggling into life, despite the smoke and mists of the grey metropolis of the north. But in other streets, such as Melville Street, as has been pointed out, nothing as yet has been attempted to give diversity to the weary platitudes of plate-glass and freestone ashlar work. The ornamental shrubbery strips in the Meadows (thanks to the taste of Mr M'Leod, city garden superintendent) now show some of the arboreal amenities we have already bequeathed to our grandchildren. But what is to be said of the new demand that her Majesty's Commissioners of Woods and Forests cover with thick tree growth the unique lion's haunch of Arthur Seat, and in whole or in part the escarpments of Salisbury Crags? A moderate amount of planting

in the area of the Queen's Park would increase its amenity. It might renew an aspect of scenery already to be found in old pictures of this and the neighbouring hills. Important scientific truths regarding the adaptation of soils to different trees might be gained were the hill an experimental station in connection with the new Forestry School. The decomposing basalts, dolerites, and the diversified rocks forming the area of the hill, render it an infinitely preferable site either to the Arboretum or the Royal Botanic Garden, which, situated on the newer formations of recent sands and gravels, have ever and anon iron bands running through them, very inimical to the maturing of shrubs and trees.

"The extension of private tree-planting, notably in villa residences, has also been proposed. This subject is the more apposite, as already one of the sides of Arthur Seat is being encroached on by streets. The city is now possessor of Blackford Hill, and its adornment in the fashion of the landscape-gardener may irretrievably mar the surrounding historic landscape, or display it in more scenic beauty. Why should not the Cockburn Association call for competitive plans, showing how planting and building might be simultaneously carried out, especially in that wide area, probably so soon to be taken from the agriculturist by the opening of the new Suburban Railway? Such plans would embrace not only villa residences and public gardens, but working-class streets, cottage allotments, and children's playgrounds. The marvellous outgrowth of the city during the last thirty years towards the south and west, shows such dreams of further growth may be other than utopian."

Extract from the 'Journal of Forestry,' November 1884:—

" *Tree-planting in London and San Francisco.*—Mary Wager Fisher writes to the 'Rural New Yorker' from San Francisco—

" 'Fuchsia, heliotrope, geranium, and plants of this order of hardiness, are left in the ground the year round. When the winter is more than usually cold, as was last winter, they are likely to freeze down, but sprout again in the spring. Fuchsias grow to be several feet in height and several feet in diameter, forming a great bush when left untrimmed, like our spiræas, and are used as hedges, while their bloom is enormous. Pelargoniums and geraniums grow to a similar size—6 to 8 feet high. I saw in Oakland, a suburb of San Francisco, an abutilon fully 20 feet high, nearly covering the large side of a dwelling-house. Oakland is an exceedingly beautiful city, and in its most fashionable quarter the lawns and gardens are wonderfully fine. They are not large, but are kept in perfect freshness by means of hose and water. A great many cypress hedges enclose the lawns; and as cypress grows here in greatest luxuriance, it bears any amount of pruning, and the trees and hedges are trimmed into any desired shape, quite as fantastic as those one sees at the Versailles Gardens in France.

" 'The eucalyptus-trees grow to a striking height, and have the drooping habit of the elm, but are more slender in form. The new leaves are of an altogether different shape and hue of green than those of an older growth, and when on the same tree they form a curious appearance. With the exception of some rows of Lombardy poplars, I have nowhere seen a

uniformity of trees planted along the streets; but willow, locust, eucalyptus, cypress, live oak, and various semi-tropical trees and shrubs, which have been chiefly brought from Australia, are planted, and the effect is very rich and luxuriant. Heliotrope grows as rankly as wild roses, but loses its fragrance after having been exposed to the hot sun. It is often trained into tree form, as are roses and fuchsias. From what I have seen, roses do not bloom perfectly, at least in the summer months, the dry weather causing the blossoms to blast. Dahlias bloom magnificently, and a plantation I saw of them in the Golden Gate Park was a splendid sight. This park has been reclaimed from "sand lots,"—over 1000 acres of sand being planted with trees, and made into lawns and flower-gardens, that are dazzling beyond description. The part that has been put in order is of exquisite beauty, the trees and shrubbery in particular being charming. The gardener told me that 200,000 had been planted this last year. The park grounds extend to the ocean; and it is curious to see acres of sand-hills planted with small pine and other trees that will grow in sand. Some of the hills are planted with a kind of sea-grass to prevent the sand from blowing, for it drifts and blows about in the wind like snow. The city of San Francisco is built on such sand-hills, and all excavations for foundations that I have seen have disclosed vast beds of sand, and nothing more stable, which reminds one of the parable of the two house-builders; but the houses here seem to stand as well as if built on a rock.' "

Tree-planting in Manchester (from the 'Journal of Forestry,' August 1879):—

"Tree-planting in towns may be fairly considered as a work to be taken into the consideration of our municipal authorities. We have more than once pointed out the desirability, for several important reasons, of the open spaces of towns being planted with trees. A month or two since we referred to a paper, read at the Manchester Town Hall by Mr Findlay, curator of the Manchester Botanical Gardens, on this subject (see 'British Architect' for October 25, 1878). Mr Findlay, in his paper, dealt with the difficulties under which trees in towns exist, and how these difficulties may in a measure be overcome. He also gave a list of the trees most suitable for town cultivation, how to plant them, and their after management. Since the meeting at which this paper was read and the subject discussed, the Manchester City Council have formed an Open Space Committee, under whose direction several open spaces in the city have been planted—viz., St Mary's Churchyard, South Parade; St George's Churchyard, Hulme; All Saints' Churchyard, and the Infirmary Grounds. The work has been carried out according to the instructions given in Mr Findlay's paper, and there is every likelihood that the experiment may prove a successful one. It is to be hoped that other spaces save churchyards will receive the consideration of the Open Space Committee, and that the sickly specimens of tree-life in the suburban streets, or groves and avenues, as they are called, may also become the care of the committee. Other towns in the cotton and woollen districts might with advantage follow the example thus set in the Cottonopolis. Tree-planting schemes of any magnitude, and likely to have beneficial sanitary effects, require time for working out; hence the desirability

of something more than the spasmodic efforts so common in connection with what may haply be termed merely philanthropic schemes. In appointing a special committee to this work, the Manchester Corporation have shown to other local authorities the right way of going to work,—an example we hope many will follow, if only for the sake of keeping the subject in mind."

CHAPTER XIII.

IMPLEMENTS FOR PLANTING.

REPORT on Trees and Shrubs in the Nursery of Messrs Peter Lawson & Son, transplanted during the Summer of 1863 by M'Glashen's Transplanting Apparatus.

At the last general meeting of the Scottish Arboricultural Society, a committee was appointed to inspect, in August 1864, a number of young trees that had been transplanted by M'Glashen's transplanting apparatus during the summer of 1863, and to report on their appearance and condition at the time of inspection. The members of the appointed committee accordingly met in the nursery of Messrs Peter Lawson & Son, Edinburgh, on the last day of August 1864, and were very kindly received by Mr Gorrie, the manager, who conducted them over the grounds, and pointed out all the plants that had been operated on by M'Glashen's apparatus between June and the end of August 1863; he also exhibited the apparatus in operation, to enable the committee to form an estimate of the expedition with which the work could be accomplished.

The first plants inspected were young ornamental oaks, varying in height from 3½ to 10 feet. Those

ranging from $3\frac{1}{2}$ to 5 feet were transplanted by a 22-inch apparatus, and those from 8 to 10 feet high by a 30-inch apparatus. All the plants had "been once watered" after removal, and at the time of inspection seemed to be quite healthy and vigorous, and apparently not at all deteriorated by the operation.

The committee next inspected a number of coniferous trees that had been transplanted at the same time,—among which were *Cedrus deodara, Pinus austriaca, P. laricio, P. pinaster, P. cembra, P. caramanica, P. Pallasiana,* weeping Scots pine, and others. The weeping Scots pine had made shoots this season of from 3 to 6 inches. *P. austriaca,* 7 feet high, had made shoots of from 6 to 8 inches. The other plants ranged from 6 to 10 feet in height, were all healthy, and growing vigorously. One plant of *Pinus Pallasiana,* about 9 or 10 feet high, had been taken out of a row of plants standing very close together, and two of which had to be cut to allow the apparatus to be used. From an inspection of the position from which the plant had been removed, the committee were of opinion that it would have been very difficult, if not impossible, to have done the work successfully with common spades in the usual way. Yet the plant had been removed by M'Glashen's 30-inch apparatus, without having suffered in the slightest degree by the operation.

Many other plants had been transplanted at the same time by the apparatus, and were each minutely inspected by the committee. None of them seemed to have suffered at all by the performance. Some double thorns, on the contrary, appeared to have benefited by the process, and produced shoots of from 3 to $3\frac{1}{2}$ feet long.

A number of coniferous and other plants that had been transplanted at the same time by common spades in the usual way were pointed out to the committee. They were mostly either dead or in a greatly debilitated and sickly condition; and few, if any, showed indications of ability to overcome the effects of the operation they had undergone.

After the inspection had been completed, Mr Gorrie produced M'Glashen's apparatus, and kindly permitted the committee to witness the methods of its application, and the time necessary to perform the operation of lifting. A plant of Irish yew, about 6 feet high, was lifted out of the ground; but stones greatly impeded the propulsion of the spades or cutters. The committee were of opinion that, under ordinary circumstances, in ground free of stones, the work might have been executed in about half the time in which the experiments they had witnessed were accomplished. They were also of opinion that the rapid action of the spades would be greatly accelerated, and the work more economically performed, by using hammers or mallets to drive the spades into the ground, instead of simply crushing them in by the action of the foot.

The committee have no hesitation in saying that the apparatus invented and patented by M'Glashen is eminently adapted to the purpose for which it is constructed, and superior in point of utility to any other transplanting apparatus or machine with which they are acquainted. They, however, consider the price charged by Mr M'Glashen to be somewhat exorbitant; and believe that the merits and advantages of the apparatus have been secluded, its general excellence and usefulness unappreciated, and its issue

limited and retarded, by the high price charged for it by the patentee.

On Transplanting Machines, old and new.

Mr Kay, forester, Bute, in the 'Transactions of the Scottish Arboricultural Society' for 1874, pp. 186-89, after some critical remarks on the various machines and appliances in use, gives a drawing and description of one constructed by himself. He says:—

"Having a number of trees to transplant in spring (1873), and there being nothing more suitable for the purpose than a common janker used for transporting logs, I carefully considered the construction of those machines that have been in use for some time, such as M'Glashen's and Mackay's (referred to in Brown's 'Forester'), as well as the old-fashioned janker. It appeared to me that none of them possessed the simplicity and power necessary for carefully lifting, removing, and transplanting trees. The old-fashioned janker undoubtedly possesses sufficient power; but the tree is put to a severe test at the outset by being torn from the ground by physical force, the roots and branches rudely dragged along the ground, and the earth jostled from the upturned root at every movement. Certainly a more barbarous way of pulling a tree out of the ground could not be devised. The construction and mode of lifting the tree by Mackay's machine is certainly more satisfactory than with the janker. Still the means of getting the wooden bars placed under the root are somewhat imperfect, and cannot bear up the weight of the tree so effectually as if placed along the outer edge of the ball, thereby straining the roots. The raising of the tree is also performed in a slow and cumbrous manner, being

effected by common hand-screws, and the chain made to pass round the planks on which the tree rests."

An account of a tree-lifter, patented by Dr Newington, is given in the 'Journal of Forestry,' November 1881:—

"A number of machines have been patented from time to time, intended for transplanting large trees, some of which are capitally adapted for doing good work; it must, however, have occurred to every one intrusted with the care of plantations, that there is a want of some mechanical assistance for moderate-sized trees and shrubs, which, although too big to be moved with the spade and the hand, are yet not sufficiently bulky to require the use of a transplanting machine.

"We learn from the inventor, Dr Newington, Ticehurst, Sussex, that by means of his instrument, conifers, forest and fruit trees, as well as shrubs of considerable size, can be lifted from the ground without injury to the roots in two or three minutes. A larch 16 feet high was brought clean out of the ground, with roots from 3 feet to 4 feet in length, in the space of two or three minutes; and an *Arbor vitæ*, 10 feet high, which had been growing in the same place for six years, was uprooted in about the same time.

"Mr J. Charlton, Parade, Tunbridge Wells, has been appointed the agent for the above implement. The price of the 40 lb. lifter complete is £2, 15s.; a smaller instrument, for plants from 5 feet to 6 feet in height, is sold, the price of which is £2, 2s. complete."

See drawings and details in November number of the 'Journal of Forestry,' 1881.

I have not seen Dr Newington's tree-lifter, and

therefore cannot speak of it; but most of the other machines and appliances I have seen, and with all due respect to them, and appreciation of their special merits, I have to say that none possesses so many advantages, and so few disadvantages, as the common but by far too little appreciated "janker." One objection to it is that the tree has to be conveyed horizontally instead of upright. That, in our view, is one of its chief merits, for it is very seldom on any road that a clear headway of 20 feet is at command, and therefore the horizontal position suits best. The roots must, of course, be protected, which is easily done, and the branches, which would otherwise trail on the ground, are easily supported on low-wheeled boggies to any degree of perfection. It is the common janker I use, and the success hitherto attending it will compare favourably with any other apparatus I have seen or known. The most common and best implement for ordinary planting of moorland is the half-worn garden spade; it answers for general purposes better than any other known or in use, and can be turned to almost any account for the purpose.

The planting-iron, which is a small and feeble implement compared with the spade, does very well for planting sandy links or arable land, where very small plants are used; but it is not so convenient for removing turf, making pits, or removing any of the various obstacles that stand in the way of properly putting in a plant. I would therefore recommend the common spade in preference to the planting-iron, which is simply a miniature spade made of solid iron, except the cross part which fills the hand, which is wood.

CHAPTER XIV.

CONCLUDING HINTS ON PLANTING.

PLANTS to be brought from a low-lying sheltered situation, or from a rich to a poor soil, should always be planted at least one season in a nursery in the immediate neighbourhood of where they are to be planted permanently.

Small plants of all sorts should be lifted and transplanted annually preparatory to finally planting out; by this means luxuriousness of growth is prevented, and a greater number of fibres is produced than by allowing the plants to stand two or three years without removal.

Plants, till they are sufficiently strong and tall, should be kept clear of long grasses, brakes, whins, &c., as these grow over the young plants, inducing them to grow bent or crooked.

The forester's footpick (fig. 1, p. 10) is a most sufficient instrument in the hands of an able-bodied man, and can be used with great advantage in preparing the ground for planting. It is not used in excavating the earth so as to form a pit, but merely to break the soil and subsoil to a depth of 2 feet; and by entering it three times around where the plant is to be planted,

the soil and subsoil are effectually broken within a circuit of 3½ feet.

Black-game are very destructive to the Scots pine when below 2 feet in height; they pick out the buds during the winter season, which is in effect cutting off the top-shoot of the young plant.

Young pine plantations should not be formed where pine timber has been cleared off till the ground has lain long enough to purify itself, or otherwise rendered fit for planting by burning, draining, trenching, and fallowing (as a substitute for liming), which is better for the growth of the trees, especially conifers. Trees must be completely protected from hares, rabbits, squirrels, and animals of all kinds that would otherwise injure or destroy them in any way, whether root, stem, branch, or foliage.

RULES FOR PLANTING.

1. Never plant ground that is not dry as deep as the roots of trees go down to fairly establish the tree.

2. Avoid deep planting—that is to say, plant so that the swell of the roots is fairly above the general surface of the ground.

3. Plant only such trees as the soil and situation will bring to the state of perfection they are intended to attain.

4. In planting small groups, the trees should be planted closer than in planting large areas, and thinning done early in proportion as the trees are close planted.

5. Plant in autumn in preference to spring, and rather in September than April. September is the

best month of the year to plant holly, and when the soil is too dry water it.

6. All large size evergreen trees and shrubs planted to endure the winter and spring winds should be well secured against the wind shaking them. It is the motion caused by the wind, rather than the intensity of the frost, that browns and withers the plants.

7. Where watering is required, it is better to give a large supply twice a-week than smaller quantities oftener.

8. The size of the tree and capacity of the roots for deriving food from the soil should be well considered, and the deficiency of plant-food supplied by either adding new and better soil, or breaking up and rendering the natural soil suitable for the sustenance of the plant.

9. The lower twigs or branches of all trees, but especially of very young and small ones, should be carefully preserved, and neither injured in planting nor interfered with afterwards by grass or rank herbage of any kind choking them.

10. Attention should be paid that no heating of the plants in transit or in the plant-bed take place, and also that no sea-water touch them, which is fatal, at least to evergreens.

SECTION II.

THINNING

CHAPTER I.

INTRODUCTION.

THE thinning of plantations is such an important branch of forestry, that every opportunity should be taken advantage of to study it and set forth its claims.

The operations of thinning either confer much good or inflict great evil, according to the skill with which they are performed.

If we study nature carefully, and accurately imitate her operations of thinning in the natural forest, we shall do well; but in this we must be both observant and accurate to the last degree.

In the natural forest the crop is sown, not all at once, as in the nursery ground, but at different times, and therefore the plants come up more or less irregular, those obtaining the precedence keeping and maintaining it; therefore the oldest and furthest advanced trees keep down and kill the younger ones, which is nature's own way of thinning.

Under peculiar and favourable circumstances small patches of natural forest, whether alder, birch, or Scots pine, will be found of nearly one age and equal growth, being the result of turf-cutting or surface-burning, which admitted the seed depositing itself, and the plants in such groups growing up equal and at one

time. Such, however, are very exceptional cases, and of limited extent, and therefore do not affect the general principle. Upon such patches I have seen the crop of trees not exceeding 2 feet apart, and from 30 to 40 feet high, and 3 to 4 inches in diameter,—beautiful clean poles, and useful in their way, but for which there was little demand, and consequently no remunerative prices obtainable for such close-grown wood.

I have found groups of several acres in extent of natural Scots pine and birch forest, and also patches of alder, wherein the sound of the woodman's axe was never heard, which in point of value, acre for acre, considerably exceeds any plantation I have ever seen. Some of the best portions of natural forest in Scotland to which I refer are, or were, upon the Rothiemurchus, Glenmore, Duthil, Abernethy, and Castle Grant estates, in Strathspey, Moray and Inverness-shires, and on Invercauld and Balmoral estates on Deeside, Aberdeenshire.

It may with propriety be asked, why the natural forests are often more valuable than plantations of artificial culture, and if all the aid rendered by man does not lower instead of elevate their condition?

In the first place, it must be observed that natural forests grow *only* in such soils and situations as are truly congenial to their natures, and will not even germinate in adverse soils; hence nature, having the choice of conditions favourable to successful growth, seldom errs, which man is liable to do, and frequently does. In the vegetable as in the animal economy, the strong, healthy, and vigorous take advantage of, subjugate, and devour the weak.

For example, we find upon an acre of ground say 800 plants of nearly one age and size, from 1 to 2

feet in height, and on minutely examining the surface another class of plants between 6 and 12 inches in height growing up, but less vigorously than the former. The latter class do not gain in growth upon the former, as might be supposed, till they overtake them, but, on the contrary, lose so much growth every succeeding year till they ultimately disappear altogether, leaving the original 800 sole and exclusive occupants of the ground, which they exultingly possess.

When once a crop of trees is fairly established, and placed under favourable conditions for growing, all that they further require is time to grow; and it is in this probably, as much as in anything else, that the secret of good forestry lies. The natural impatience and impulsiveness of man lead him constantly astray, and in nothing more so than in the culture of trees. In the natural forest, where no labour was bestowed, no recompense is looked for or sought: where no money has been expended, no interest need be claimed; where nothing has been given, nothing should be required. Hence the goodly old natural forests, that have been allowed to stand and grow to maturity during two or three centuries, alike uncaring and uncared for, till some accidental circumstance,—like the opening of a railway, diminished foreign supplies of timber, insolvent proprietor, or some pressing local demand for wood at home,—awakens the happy thought of cutting and clearing 1000 acres or so at a sweep, and realising £100 per acre—by no means a high figure, comparing it with what I have seen in the districts referred to, where many acres may be found worth considerably over twice that sum.

Not a few are of opinion that there is a distinct variety of the *Pinus sylvestris*, called in the Highlands

the Bonnet fir, so designated from its rounded dome-like top, pendulous branches, and peculiar red and strong bark — (all the result of soil, climate, and situation),—differing from the south country pine in every respect to such a degree as to produce those distinctive features, alike marked and conspicuous. That this is purely imaginary could be easily demonstrated and proved; but meanwhile I may remark that the snow which falls more plentifully in these Alpine districts than in the Lowlands and southern parts of the country, greatly contribute in imparting to the trees the characteristic features of the Bonnet fir. By the weight of the snow the top is often so much broken and crushed as to assume its dome-like and pendulous shape. The soil, too, which is dry, hard, and gravelly, imparts to the timber those qualities for which it is so justly celebrated; and the age which it is thus allowed to attain being at least double that which plantations in general are allowed them, crowns and completes the list of qualities for which the native Highland pine fir is so justly celebrated.

The growth and culture of forest-trees, however, being a means of accomplishing an economical and industrial end rather than that of merely fulfilling a law in nature, or accomplishing mere natural results, we shall be led subsequently to inquire how far artificial thinning of woods and plantations is conducive to these results.

While planting may justly be regarded as the operation of putting the tree into its proper place and position to grow, thinning may with equal propriety be considered the handmaid to the process of growing it. If a tree is improperly planted, whether as respects place, position, or otherwise, no future treat-

ment, however skilfully or judiciously performed, can ever compensate for the loss, or overcome all the injury done. But, on the other hand, however well a tree may be planted and placed under the most favouring conditions for growing, the whole prospects may be, and very frequently are, completely blasted by improper and injudicious thinning.

Mixed plantations are, at all stages of growth, more difficult to thin, require more constant attention, and are more easily injured for want of it than those composed of only one species of tree. Different species of trees also require different modes of thinning, and even the same species grown under different conditions require very different modes of treatment.

Thinning, like pruning, may be justly enough regarded as a necessary evil, an antidote for a bane, a cure for a disease—or at the most, art doing under an artificial system what nature can usually better accomplish if left alone without such aid. It is no sufficient objection to thinning merely that it is an artificial operation rather than a natural one, because the whole system of tree-culture, whose ultimate object is the fulfilment of some artificial requirement, is essentially artificial.

The simplest form of thinning is that of cutting down such growths as interfere with the healthy development, value, and usefulness of the remaining crop, and it is this form of thinning that has probably suggested the term "weeding." There is certainly more reason for the use of the term "weeding" than at first appears; for according to Mr Stephens's 'Book of the Farm,' a weed is defined as signifying a plant growing where it should not grow, or where, for the time being, it is not desired it should grow. The

term itself is, however, of the smallest moment, while the operation and effect are of the very greatest consequence. The growth of forest-trees, as is universally known, is at the fastest but a slow process; while, on the other hand, the cutting down or work of thinning is the very reverse. Two trees have grown up together, it may be ten, twenty, or thirty years, unmolested, undisturbed, and underanged in any of their functions, and having thus grown up, they have completely adapted themselves to each other, and formed powerful attachments, and in a very important sense formed strong affinities for each other.

In this state and condition the two trees are found growing and doing well; and so on with the others, pairs, triplets, or larger groups throughout the whole plantation or forest. Then, why and wherefore break up this long-cherished connection and friendship, and disturb the congenial relationship of those well-doing pairs, since they have grown so long and so well together? The answer to this compound and complex question must of necessity be of very considerable length, but will, it is hoped, be found fully answered in the sequel. Trees, like everything subjected to growth and development, are constantly undergoing change, sometimes more rapid and sometimes less, according to an infinity of prevailing causes and influences which surround them. In thinning forest-trees, two primary considerations are to be kept constantly before us. The one is the full, free, and perfect development of every part of the tree, so as to produce vigorous growth and prolonged life in the tree itself; the other is the growing of the tree so as to form the best and most suitable subject for some one or other of the many requirements of art or industry.

In the growing of a group, plantation, or forest, several important changes are gradually yet imperceptibly taking place upon the trees both individually and collectively,—upon the soil on which they grow, upon the surrounding atmosphere and climate, and consequently upon every subject in the whole neighbourhood and district.

What these changes are, how they are produced, what takes place when the producing causes or active influences are removed, are considerations alike important and worthy of investigation. It is self-evident that as two or more trees approach each other —which they do in a threefold way, namely, by the points of the lateral branches elongating themselves and annually extending their young shoots, by the roots mixing, interlacing, and sometimes even grafting each other in their subterraneous ramifications, and in the annual enlargement and increased diameter of their stems or trunks—other and different changes are also produced upon the soils in which the trees grow, and different species of trees also produce different results.

The changes produced upon the soil may also be regarded as of a twofold nature—namely, chemical and mechanical. The chemical changes produced are alike obscure, difficult to trace or comprehend; nor has science done much, if anything, to throw light upon the dense darkness, or reveal what is unknown or hidden. That the constituent parts of the soil are not the same after having produced a crop of wood or timber as they were before is certain, but whether the change is produced by something being abstracted or imparted, is, and may remain long, a mystery. The mechanical changes produced, however, are most observable and obvious to the senses. The roots of the

tree, as they year by year force their way through the soils—first through the active and then through the subsoil — thereby disintegrate the adhesive compact parts, whether of earth or rock, and thus pulverise the soil and admit air and water to mix and mingle with the deeply embedded substances, thereby altering and changing their composition by a slow but certain process.

All trees, at one or other of their successive stages of growth, are either susceptible of vast improvement by thinning, or of being injured almost to complete ruination by doing it. Some, certainly, are less injured than others; and some species, if once injured, can never by any future treatment be at all restored to vigour of growth. Amongst hardwoods, the ash, of all deciduous trees, is the one most easily injured by want of thinning and most benefited by it; but if once neglected, even for a few years, all its prospects are for ever blasted. Amongst coniferæ, again, the Scots pine, on the one hand, either benefits most by thinning, or, on the other, suffers most for want of it.

The Scots fir (*Pinus sylvestris*), whether regarded from its importance as a tree, a crop, commercial or industrial product, demands special consideration in regard to thinning. It is generally admitted to be the most extensively planted tree in Great Britain (certainly in Scotland), and is justly esteemed, both on account of its commercial and industrial value, and its adaptability to a greater variety of soils and situations (especially that of the poorer description) than any other forest-tree; and from these and correlative circumstances has arisen the saying, almost amounting to a proverb, "Thriving like a Scots fir."

Although this is substantially true, it is not abso-

lutely correct, for there are soils here and there to be found, though comparatively rare, capricious enough to refuse even to grow this proverbially hardy tree. It is, however, usually on account of the excessive richness or hardness, and not the poorness of the soil, that the tree refuses to grow in it.

Thinning is a lever in the hands of the forester of immense power and importance, by which a crop of Scots pine may be made profitable or unprofitable, good or bad, according as that power is exercised.

It is still far from being universally known, that although gravel, sand, and dry soils generally are the best and most adapted to its growth, yet upon such soils, where the best crop should be grown, the very opposite results are often brought about, through injudicious and inopportune thinning. The writer could point to hundreds, if not thousands, of acres of Scots fir plantations in Scotland where the market value, no less than their other worth, has been diminished by from one-third to one-half, and in some cases considerably more, simply on account of thinning being done at the wrong time. The terms injudicious, improper, inopportune, and suchlike, though familiar to the ear, yet convey no definite or distinct idea, nor point out what should or should not be done by way of thinning; and therefore it is all the more necessary that we should endeavour to make the subject as clear and plain as possible.

One principal reason why thinning is rendered such an immense power for good or evil, is in consequence of the change of temperature it produces upon the soil. When trees are planted in their young or seedling state, they, like most other things when young, readily adapt themselves to their circumstances—such

as climate, soil, and situation, to which they have been transplanted,—and by progressive but imperceptible degrees they grow up, expand, and gradually shade and completely cover the ground, till not a ray of the sun directly reaches it. The branches and foliage of a plantation constitute a sort of canopy whereby the surface of the ground is completely shaded from the rays of the sun, and consequently never, even during the hottest weather, does the ground become greatly heated: that is to say, the ground in a plantation is less heated in hot weather than it is where there are no trees; and again, in winter, it is warmer in the plantation than outside of it. Every person knows that it is cooler and more enjoyable to sit under the shade of a tree, on a hot summer day, than under the direct rays of the sun; and the footsore and weary traveller can cheerfully testify to the relief he experiences and the joy afforded him by the shade of a spreading tree across his path. If any one wishes to experience the great difference between the temperature of the soil on a hot summer day under the shade of a tree, and that beyond it, he has only to walk leisurely along, and with his eyes closed, though walking in thick-soled boots, he will at once feel and determine the limits of the shady part of the footpath. This being clearly demonstrated, the whole subject relative thereto may be known, and the results sufficiently ascertained.

The shading of the rays of the sun from a few acres, or even miles of ground, may produce comparatively little effect upon an extensive country; but when hundreds of square miles are covered from the face of day, so that neither light nor heat reaches the earth for ages in succession, the results cannot but be im-

mensely great, extending far beyond what even the imagination can conceive. It is from this cause that springs, streams, and rivers that have flowed uninterruptedly for generations through the shady forests of foreign lands, and specially in Syria, Palestine, Egypt, &c., were all dried up when the forests were cut or destroyed by fire, and the inhabitants forced to change their abodes for want of water, even for domestic purposes.

On the Marquis of Lothian's estate in Roxburghshire, an extensive Scots pine plantation or forest was formed, and as it grew up and shaded the ground, a naturally damp part in the plantation gradually became a spring of considerable strength, so much so that a gamekeeper's house was built near by for the sake of the water. By-and-by thinning was carried on, and afterwards the wood by degrees was cut for estate purposes, till the fine old plantation was nearly all cut down, during which time the spring was as gradually falling off as during the plantation's growth it was increasing and gathering strength and volume. On the same estate, and distant from the above some two miles, was another well, which also increased in strength as the plantation thickened around it, and again decreased as it was thinned and cut down. It is generally though not universally known, that the roots of the trees spread underneath the ground much in the same way as the branches do above it; and it requires no stretch of imagination to conceive how the roots thus formed and developed under the cool shade have acquired such a constitution and habit, that if changed or altered in any important way (as is done by the operation of thinning), effects the most baneful must necessarily follow. When a single tree in the

centre of a group is cut down, the roots of all the other immediately surrounding trees equally suffer.

If the trees, when thinned, are young, vigorous, and full of sap, they in a comparatively short time recover their wonted luxuriance and vigour of growth; but if considerably advanced in years, their recovery is much more protracted, or perhaps may altogether fail.

Practical forestry, I consider, may be defined as signifying the growing of the greatest quantity of the most valuable wood or timber upon the smallest piece of ground in the shortest period of time. To grow a large quantity of wood is a very desirable thing, but the operations of forestry may and often are so conducted as to increase the quantity at the expense of the quality. We have all seen large bulky trees, so coarse and knotty and open in the grain as to be unfit for almost anything. Scotch fir, for example, grown on rich loam, or on certain descriptions of moss-land, is of such rapid growth as to render the wood useless for almost anything except fuel. Quantity of wood produced is therefore no true index to good forestry, but when combined with quality, the case is essentially different. The largest and best are qualities sought for in a tree; and it is hoped that in the sequel it will be shown how, by thinning, they can be produced.

The size and quality of a tree are also in themselves very good; but wood as well as gold may be bought too dear, or cost too much, and if gold may be bought too dear, wood may also be grown at too great an expense: and when this is the case, practical forestry cannot be said to be successfully accomplished. One thing above most others very

materially influences the value of wood—that is, the cost or value of the ground it occupies during its period of growth. If the ground, for example, at 10s. per acre can be made to grow as much timber of equal quality as another acre can at 15s., it must appear evident that the former is the most profitable, and such only as should be planted. As certain descriptions of ground, however, grow certain species of trees better than others, an important consideration here arises as to what species of trees to plant upon the different kinds of soil. The importance of this matter is paramount, because, in the first place, when once the trees are planted they in a sense grow of themselves; hence it becomes every planter's duty to see well to it that only suitable trees, *and no others*, are planted.

The length of time which a single tree or crop of trees takes to attain maturity, or its highest possible value, is an important matter; because if one forester can grow a crop of trees as valuable in fifty years as another can in sixty, then ten years would be thereby gained, which would represent one-sixth of the producing cost, &c. When these and other relative matters are kept in view, the operations of true practical forestry become better understood, and the modes of carrying them out greatly simplified.

In addition to profit, however, we have also shelter, which consists principally of belts, strips, groups, and single trees, the object of which is to produce warmth and shelter to animals in the fields, and dry and ameliorate the climate. This branch of forestry is, however, more an auxiliary to farming, and a means of making arable and pasture lands pay, than that of producing profitable returns from planting.

Indeed, trees grown either as small groups or narrow belts will not fulfil all the conditions laid down for practical, profitable forestry. We have also ornamental forestry, differing from the other two in almost every respect. Ornamental forestry comprises hedgerow trees, lines, and groups distributed over the landscape, and single trees, so grown, either alone or so combined, as to produce better known than definable results.

Experimental forestry is also another branch which embraces the pinetum, shrubbery, and certain departments of the nursery. It is designed to grow trees of new importation, to see what they will attain to, find out how certain species of trees enjoy or dislike each other's presence, how certain trees thrive in different kinds of soil, &c. These are all interesting, instructive, and important branches of forestry, and should be studied and practised separately, and each in accordance with the importance it demands.

If thinning were rightly understood and attended to, pruning would be almost entirely unnecessary; for it is either from superabundance of room on the one hand, or too limited space on the other, or from having stood too closely together at one stage of their growth and receiving too much room at another, that produces most of the cases necessary for pruning. We shall endeavour briefly to show how far and to what extent thinning is necessary in order to produce the desired results of practical, profitable forestry. I have stated that quantity is required—I mean quantity of timber, not number of trees; for while it is true that two sixpences are equal in value to one shilling, it does not follow that two small trees are of equal value to

one large one. Two trees containing 20 cubic feet each may be of as much value as one containing 40 feet, but two trees containing only 10 feet each are not so valuable as one containing 20 feet, nor four trees containing 10 feet so valuable as one tree containing 40.

CHAPTER II.

MARKING FOR THINNING.

UPON many estates it is the forester's practice to keep fewer workmen during the hay and harvest months than at any other time of the year, it being arranged that the men are to have the privilege of going to such work in order to earn higher wages, as a set-off against the comparatively low rate paid them during the remaining part of the year, which is a direct advantage to the men themselves, and probably an indirect one to the estate and the farmers generally. As a consequence, this reduction of the workmen allows the forester an opportunity of attending to other matters more closely and assiduously than he could otherwise do, such as marking wood and timber, valuing, examining, or inspecting the woodlands under his care, all of which requires to be done leisurely and with caution and forethought, when the mind is tranquil and comparatively free from other cares and concerns. As the most important part of that branch of forestry termed "thinning" consists in selecting and marking the trees to be cut, I shall endeavour to point out some of the most essential points to attend to in the art and practice.

The health of a tree, generally speaking, is very

correctly indicated by the state and condition of its foliage; and at no season of the year is this so perfectly seen as when it is in full leaf and before it assumes its natural autumnal tints. All important and minute inspections as to health and condition of woods, forests, plantations, and individual trees should therefore be made in the summer season, in preference to any other. During the months of July and August I usually examine all the plantations and ornamental trees under my charge, but specially the young ones, in order to form a correct opinion of their condition of health, state of growth, form, and habit. The requirements of thinning, now that the trees are fully clothed, are much more easily seen than in winter, when they are naked; therefore full advantage should be taken of marking all trees necessary to be cut during the ensuing winter and spring. While I recommend this as the best time for marking and judging of the health of both plantations and individual forest-trees, I consider it, at the same time, to be the worst time of the year for cutting, unless for the express purpose of benefiting the remaining crop, or doing the first thinning, when no regard is paid to the trees cut beyond inducing them to decay and disappear as fast as possible, which they speedily now do if laid flat down upon the ground, that grass and other herbage may grow over them.

The distance at which the trees were originally planted, rapidity of growth, exposure, &c., all contribute in determining the period at which thinning should commence; and assuming that the trees were planted $3\frac{1}{2}$ feet apart—a common distance in small plantations and shelter belts, consisting of Scots pine, larch, and spruce, and grown at an average rate—I provide my-

self with a light but strong sharp hedge-bill, and proceed to work by cutting or slashing the tops off all those destined to be thinned out, leaving the crop upon the ground at about 7 feet apart, or say 800 trees to the acre. In thinning I do not usually mark dead trees, as they always sufficiently distinguish themselves, and the woodmen only require to be told to cut all such wherever they see them. This, then, constitutes the first and primary thinning.

The second thinning of pine and fir plantations should generally be done at about twenty to thirty years' growth, when the thinnings are of some money value, and are useful for stackyard purposes, props for coal-mines, fencing-posts, cordwood, &c.

If the thinnings, after being marked, are to be bargained for and sold standing, the marking—or rather, the counting and booking—must be very carefully done,—more so, at least, than is necessary when cut by the proprietor's own men and disposed of privately.

When marking for sale standing, I use a light sharp hand-axe, with initial letters of the proprietor's name or estate upon the head of it, with which each individual tree is stamped; and it is necessary to examine closely from time to time, and even slightly to vary the stamp, so as to check any attempted counterfeit of it. In doing this kind of marking, it is necessary to have an assistant to do the mechanical part of the work, and thus allow the forester freedom for giving directions, counting the trees, and booking them, which latter he does by putting a stroke for each tree, completing each five with a stroke across from left to right, thus ~~////~~, which facilitates the work of adding, and secures correctness by relieving the mind and breaking the tedium.

In marking standing mature timber, say oak, the following is my method: I first provide myself with a pole 14 feet long, a marking-axe with initial letters, a paint-brush and red paint, a foot-rule with slide, and a leather strap 20 feet long, made out of a seasoned gig-rein, reduced to three-quarters of an inch broad, and marked like a tape-line on the one side, and similarly marked on the other—with this difference, that the one side allows one inch for every foot of circumference as allowance for bark, while the other makes no such allowance, being used only for measuring peeled timber. The pole is also graduated and marked with figures, beginning at 6 feet from the ground, and marked in feet and half feet to the top. The slide is used for casting up the contents, but in extensive practice is seldom made use of.

The strap may be any convenient length, from 15 to 20 feet, three-quarters of an inch broad, and of the strength of a small bridle-rein, with a piece of lead attached to one end of it to make it swing around the tree. Previous to marking the strap with the necessary figures, the leather should be alternately wetted and dried, otherwise it is apt to shrink and expand when in use, according to the state of the weather. A seasoned gig-rein, when reduced to proper dimensions, forms an excellent strap. Such straps, so far as the writer is aware, are not to be bought, but must be home-made, and marked as in fig. 2: 6 being the first figure upon the strap, is exactly 26 inches from the end, including the lead, and is the side of the square.

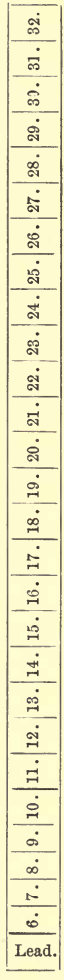

Fig. 2.

The next figure is 7, being 27⅔ds from the end of the strap, and so on. The cross stroke indicates half inches; quarter inches for common practical purposes are seldom used, but are indicated on the strap by a dot, and may be used if required. The pole used for taking the height is 14 feet long, marked feet and half feet. The lowest mark is at 6 feet, at which height the trees are mostly girthed; thus, by an expeditious and simple process, the contents of the first 12 feet of the trunk are found. This is a simple, expeditious, and safe method of measuring standing timber, either for sale, transfer, or other purpose,—a method, in the writer's experience, surpassing for speed and accuracy all others that he has either himself tried or heard of; but one, at the same time, the accuracy of which depends upon matured judgment and experience.

Though the use of the slide-rule is recommended for casting up the contents of a tree, yet in extensive practice it is seldom used. Having the length of the section (or whole tree), as indicated by the pole and the girth, by which the side of the square is shown, as indicated on the strap, by passing it round the tree the relative proportions of length, girth, and contents soon become so familiar to the mind that no casting up is required. A few examples will show this. Taking the section at 12 feet in length, the following are the results sufficiently near for practical purposes:—

12 ft. long,	6 in.	side of	the square,	¼	of length,	3 ft.	true contents.
Do.	7	"	"	⅓	"	4 ft. 1	"
Do.	8½	"	"	½	"	6 ft. 3	"
Do.	10	"	"	⅔	"	8 ft. 4	"
Do.	12	"	"	1	"	12 ft. 4	"
Do.	14	"	"	1⅓	"	16 ft. 4	"
Do.	15	"	"	1½	"	18 ft. 9	"
Do.	17	"	"	double	"	24 ft. 1	"
Do.	21	"	"	triple	"	36 ft. 9	"
Do.	24	"	"	quadruple	"	48 ft. 9	"

The relative proportions are easily remembered, which greatly assist the measurer in arriving at the contents of a tree. The intermediate figures soon also become familiar to the mind when extensively in practice. In making the strap, it is advantageous to mark one side with white paint for measuring peeled timber, when no allowance is made for bark; thus the side of the square of a tree 3 feet in girth is 9 inches. The other side may be marked with red paint, allowing for bark at the rate of 1 inch to the foot in girth; thus the side of the square of a tree that girths 3 feet is indicated upon the strap $8\frac{1}{4}$ inches, and so on in the same proportion throughout the whole length of the strap.

CHAPTER III.

HOW THINNING PINE AND FIR PLANTATIONS SHOULD BE DONE.

One of the largest Scots pine plantations in Strathspey, originally planted with about 2000 trees to the acre, or say $4\frac{1}{2}$ feet apart, the object of which is to grow heavy mature timber of first-class quality in the most profitable way. Such plantations are recommended to be thinned to about 800 trees per acre as the crop.

The first thinning is recommended to be done when the general crops are from 4 to 6 feet high, and probably six to eight years old. A good woodman is able at that stage of growth to thin an acre, less or more, in two days, at a cost of 5s. to 6s. per acre. The thinnings may be counted as of no money value, because if cleared out they are not worth more than the cost of the labour. The plantation, thus once thinned, need not of necessity ever again be thinned, but may grow till ripe for cutting and clearing.

Some of the most profitable pieces of Scots pine woods and plantations in the kingdom are those (whether by accident or intention) that have been grown on these or similar principles.

This primary thinning is best done when the work-

men are sufficiently experienced to be able to thin out the proper trees without their being marked, because the time and labour of marking would at least do half the cutting. The work is done by means of the famous hook-bill, improved and manufactured by R. Sorby & Sons, Sheffield, and sold by T. Methven & Sons, nurserymen, Edinburgh, under the name of Michie's improved bill-hook, of which fig. 3 is a representation. It will be observed that the handle is thoroughly adapted to the hand, so as not to be held too tight, and the weight of the instrument is towards the point, and only so far curved as to protect and preserve the back part of the blade.

Fig. 3.

Some of the most valuable Scots pine plantations, or patches of them, we have ever seen are those in which the trees stand not more than 8 to 10 feet apart. We are well aware this practice of thinning recommended for Scots pine is objected to by some foresters, but that of itself neither makes the practice right nor wrong. Our reasons for so thinning are because the work is done at a period of the plantation's growth when it can be done cheaper than at any subsequent period; and though, as already stated, no revenue can be derived from the thinnings, it will yet be found in practice to be cheaper, and pay better ultimately, than any other system.

[TABLE OF THINNINGS.

TABLE OF THINNINGS.

No. of Plantation.	Name of Plantation as per Estate Plan.	Thinned out in		Value of Thinnings.			Cost of Work.		
		Year.	Trees.	£	s.	d.	£	s.	d.
1	A	1869	3850	108	5	7½	23	6	1
2	B	"	...		...			...	
3	C	"	3902	158	10	4½	20	19	0
4	D	"	...		...			...	
5	E	"	800	15	0	0	2	0	0
6	F	...	...		...			...	
7	G	...	...		...			...	
8	H	...	...		...			...	
9	I	...	...		...			...	
10	J	"	3000		...		3	0	0
11	K	"	500	6	5	0	1	10	0
12	L	"	600	7	10	0	6	0	0
13	M	"	300	10	10	0	8	0	0
14	N	"	500		...		0	12	0
15	O	"	25	2	10	0	0	5	0
16	P	...	...		...			...	
17	Q	...	...		...			...	
18	R	...	...		...			...	
19	S	"	200	2	10	0	0	10	0
20	T	"	438	177	12	0	1	5	0
21	U	...	...		...			...	
22	V	...	...		...			...	
23	W	...	...		...			...	
24	X	...	...		...			...	

CHAPTER IV.

VARIABLE EFFECTS OF THINNING.

An example of the injurious effects of thinning a Scots fir plantation came under our observation in Morayshire a few years ago. The plantation was between thirty and forty years old, and the soil a dry gravelly one, with a herbage of short heather. At about twelve years old it had received what appears to have been a fair thinning, rather under than over-done, and probably no other thinning had been done till shortly before the time we saw it. The appearance it presented at the time was that of a very sickly slow-growing plantation; the foliage was short, clustered, and of a pale light-green colour. The forester in charge became alarmed at the appearance of the trees, thinking they were all about to die, and was not a little cheered when we assured him that it was only the effects of recent thinning, and that if he allowed the plantation to remain undisturbed for a few years it would again recover. The injuries inflicted were through the pores becoming dried up by reason of the heating of the ground. What we recommended was, in the first place, to cease grazing in the plantation, so as to allow as much herbage to grow up as possible, and also to allow the dead

branches to remain lying on the ground, for the purpose of retaining moisture, and producing even a little shade. Plantations of this sickly mis-thinned description are unfortunately too common, and may be met with almost anywhere; and it is therefore strongly recommended that those whose interest is at stake in such matters should make it known to others as far as they can.

Looking forward to the future prosperity of the permanent crop, it will be found that by thinning at a very early age no serious check is ever inflicted upon the growing trees, and that they even continue growing as fast after being thinned as they did before; but it is far otherwise with older and advanced plantations, which, in almost all cases, fall off in growth considerably for several years after thinning. Another evil in allowing Scots fir plantations to be far advanced before thinning is, that their side branches thereby lose their vitality at too early a stage of growth, and which, when once lost, is never again restored.

A third objection to deferred thinning is, that the trees are thereby prevented from properly rooting; and want of roots is an evil that cannot be overestimated, for on the condition of proper rooting the growth, development, and stability of the tree entirely depend. In addition to these obvious and conspicuous evils, there is yet another, which, though in some respects less prominent, is yet equally real and even more mischievous than any of the preceding —namely, that of inducing the rays of the sun to fall directly upon the ground, thereby unduly heating it and evaporating the moisture, which is thoroughly essential to the proper growth of all well-grown Scots

fir plantations. We have not by any means overlooked the circumstance that by very early thinning the trees are thereby allowed so far to spread their branches as to become comparatively bushy and unduly thick in stem (for a time) compared with their height. Now there is not the slightest need of apology for these *apparently* unfavourable results; for it is just as unreasonable to look for a full-grown man in one who had not first been a child, as to look for a stately well-proportioned tree without its first undergoing all the necessary preliminary stages of growth. The bushy tree, with spreading branches, shows conclusively that it has already furnished itself well with corresponding proper roots, and at the same time made ample provision for continuous and rapid growth for all future years, even to old age. The branches, too, as may well be understood from their distance apart, cannot increase beyond the limits assigned them; and if the trees are 9 feet apart, it is quite evident the branches of each tree cannot be more than $4\frac{1}{2}$ feet in length; and the length, again, so far regulates the girth, for there is always a corresponding proportion between the length and thickness of the branches, just as there is between the length and girth of the stem.

If the plantation is to be cut down as mature at, say, sixty to seventy years old, it is better that nothing farther be done to it by way of thinning, except cutting down dead or damaged trees.

The less disturbance of any kind that is given to a Scots fir plantation, and the more it is left to nature from first to last, the better, as nothing is more injurious, either to the individual tree or the plantation as a whole, than subjecting it to any sudden change, such as admitting strong currents of air, or the direct

rays of the sun to dry and heat the soil. A cool shady place and equal temperature suits it best.

The system of thinning young plantations the first time, with the object of deriving profit from the thinning, is very objectionable. Not that there is anything wrong in disposing of the thinnings to the very best advantage, but the profits spoken of as derived from thinnings have done so much to mislead proprietors, and induce them to injure, if not ruin, their woodlands, that the system should be unsparingly denounced. We saw a plantation lately which had been thinned for pit-props, and it was sad to see most of the fine growing and best-proportioned trees cut down, and the coarse and weakly ones left as the crop,—many of the latter so weakly that they could scarcely sustain their own weight. A report set forth this plantation as an example of profit, and showed that it yielded, as thinnings, in a given time, from £8 to £10 per acre. But the same report should also have stated how much thinning had reduced the value of the permanent crop. On some estates a large revenue is derived from what are termed thinnings, although the plantations are so over-thinned already that they are suffering severely from it. I know young Scots fir plantations being thinned containing only 200 trees per acre, and some also containing scarcely half that number. Thinning is a very general and convenient term, and is understood and practised by many foresters very differently. Cutting down the tender sapling as a weed of a few years' growth is termed thinning, and the operation of felling all but the last tree of the matured old forest is known by the same term. The two greatest errors amongst foresters are—being too late in commencing to thin, and continuing

the operation too long. It does much good if done early enough, and equally much harm if done too late.

An important example of the good effects of thinning is recorded in 'Fraser's Magazine' for September 1879 by Mr J. A. Froude, in his account of Woburn Abbey and surroundings, in which he incidentally refers to the celebrated wood called the "Evergreens." Though a mixture of other trees was planted along with the oak, it was yet intended for a true and pure oak plantation. At that time, as well as now, there had evidently been differences of opinion about thinning, for the historian Froude says: "Four remarkable books, now scarce and costly, two of them by the Duke himself, and the others by his famous gardeners, Sinclair and Forbes, testify to the useful patronage which the owners of Woburn have long extended to the arts of agriculture, forestry, and botany. John, Duke of Bedford, the great patron of agriculture, was also famous as a planter. The park owes to him the 'Evergreens,' a plantation of 205 acres on the Woburn and Ampthill road, which he planted in 1745-46, and thinned at the proper time, in spite of his gardener, who, on receiving directions as to the thinning, replied, 'Your Grace must pardon me if I humbly remonstrate against your orders; but I cannot possibly do what you desire, since it would destroy the young plantation and seriously injure my reputation as a planter.' The Duke replied, 'Do as I desire you, and I will take care of your reputation;' and as soon as the thinning had been effected, he had a board fixed by the roadside on which the following notice was written: 'This plantation was thinned by John, fourth Duke of Bedford, contrary to the advice

and opinion of his gardener, when twenty-five years planted.'"

The next Duke, John, the author of 'Pinetum Woburnense,' says in the 'Farmer' that his love for conifers was a hereditary taste. It induced him to form a pinetum in the pleasure-grounds, which rivalled the collection at Dropmore. The "Evergreens" plantation is now 143 years old, and is one of the finest in Great Britain, all the excellences of which it may justly and truly give early and proper thinning full credit for accomplishing.

CHAPTER V.

GOOD EFFECTS OF THINNING.

Thinning larch plantations is conducted in some respects the same as Scots fir, but in other respects considerably different. In some situations thinning should be done very early, as in ravines and sheltered places, while in exposures it should often be considerably delayed. In sheltered places, wherein the top growth is rapid and luxuriant, often over 30 inches annually—in such situations thinning should be done before the side branches touch each other. When this is not attended to, the trees become disproportionably tall in comparison with their thickness. We have uniformly recommended, as a reliable and safe guide to thinning, that the tree be maintained as many inches in girth near the ground as it is feet in height,—that is to say, when 15 feet high, it should girth 15 inches; when 30 feet high, it should girth 2½ feet; and when 60 feet high, 60 inches in girth: and these proportions should be duly maintained during the whole period of thinning. In larch culture, it is found, the tendency of the tree is to grow disproportionately tall in comparison to its girth; and where this disposition in any case appears, thinning should at once be resorted to. Any strained effort at perfect

regularity of the trees upon the ground should be avoided, for however desirable this is theoretically, yet in practice it cannot be attained. A plantation, for example, contains 2000 trees per acre, at which distance they stand about 4½ feet apart; after thinning is once commenced the trees cannot again be equidistant till one tree is taken out from between each two, and then there are not, as might at first thought be supposed, 1000 trees left upon the ground as the crop, but only about 500. Neither is it imperative that the trees be all of the same size; to attempt this would also be vain and fruitless, for it would imply not only equality of seed and seedlings, but equality of all the varied conditions under which trees are grown. Of all trees in the forest, none are more accommodating or easily influenced for good or ill by thinning as the larch. We saw, some years ago, a larch-tree on the famous Culbin Sands near Forres, in Morayshire, which had stood over twenty years, without attaining over 4 feet in height or three-quarters of an inch in diameter. After that date it was relieved of other trees confining it, when, like magic, it started into growth and grew most rapidly.

Another remarkable example of extraordinary accelerated growth in a larch-tree came under our own observation in the policies of Cullen House a few years ago. It was found necessary to cut down a larch-tree for a particular purpose; and after the tree was cut and laid down in the sawmill-yard to be sawn into scantlings, we noticed something very unusual in the appearance of the rings or annual growths, as shown at the butt-end of the tree. In order, therefore, to know the cause of such peculiar growth, the tree was

first sawn longitudinally right through the centre; and when this was done, it presented the most unusual and unaccountable appearance of anything of the kind we had ever before seen or heard of. See fig. 4, showing an end section. The united concentric growths of seventy-three years only measured 3 inches diameter of the tree, some of them so very minute that they could not be seen by the naked eye. After that date, beginning with the seventy-fourth year's growth, the annual zones at once increased from that of less than the thirty-second part of an inch, to that of fully one-eighth of an inch, and some years to fully one-seventh of an inch; and this increased growth was maintained till the one hundred and seventh year of its age, when the tree, as already stated, was cut down. At first we were quite at a loss to account for these most extraordinary phenomena, both in the excessively small zones at first, and those unusually great at last. The tree, as we afterwards discovered, had been originally planted in the centre of four hardwood trees, probably ash or elm, but which could not be determined, owing to the advanced state of decay of the stools. Four of the stools were found within 4 feet of the larch on all sides. The hardwoods in question had evidently been cut down about thirty-three years previously, and

Fig. 4.

thereby afforded room, light, and freedom to the tree. It grew on peaty soil, somewhat soft and moist; and it is just possible the moisture might have had some, perhaps very considerable, influence in producing these extraordinary and probably unparalleled, or at least unobserved and unrecorded, results.

CHAPTER VI.

EFFECTS OF THINNING ON ADVANCED PINE PLANTATIONS.

It is often asked what rule can be given, and how it may be known when either individual trees or plantations have the proper quantity of branches upon them. The rule for this is, as far as any rule can be given, to maintain a due proportion of girth to the height of the tree, and these proportions, as already stated, are girth in inches to feet in height, measuring immediately above the swell of the roots. For example, a tree 12 feet high should girth a little above the swell of the roots 12 inches; a tree 24 feet high, 24 inches; and so on up to 30 feet in height, to a corresponding number of inches in girth. When trees have attained the above height, thinning should be discontinued; and it should frequently not be prolonged after the trees are from 20 to 25 feet in height, but allowed to grow undisturbed (except by cutting down dead or decaying trees) till ripe for finally cutting and clearing.

That there is a danger of trees having too many as well as too few branches, is fully admitted, but there is no danger of very young trees having too many; and if the rule given be observed, there will be neither superabundance nor deficiency of branches at any time, for if the proportional girth is too great, it can soon

(if there are sufficient trees upon the ground) be reduced.

Having found out, by careful study and observation, that a well-proportioned and properly-balanced tree measures as many feet in height as it girths inches, I was further anxious to know what proportional weight the branches of such trees bore to the stem on which they grew; and in order to ascertain this, I cut down, in the process of thinning, some specimen trees of the following species, and after carefully weighing them, I found the following results:—

Species of Tree.	Age.	Height.		Girth.	Weight of Stem.	Weight of Branches.		
		ft.	in.	inches.	lb.	st.	lb.	oz.
Larch, . .	19	27	0	20	91	1	11	0
Do. . . .	10	13	6	14	23	1	4	0
Do. . . .	7	4	4	3¾	1½	0	0	12
Norway spruce, .	10	10	6	8	12	0	2	0
Do. . . .	7	4	3	5	2¼	0	2	0
Do. . . .	7	4	5	5¼	2	0	1	4
Scots pine, . .	36	27	5	30	224	12	3	8
Do. . . .	26	20	4½	22¾	89¼	6	5	0
Do. . . .	20	15	5½	13	27	1	0	0

The height and girth in the above table are not exactly proportional, as it is very difficult in making a selection to find them so, but the approximation is sufficiently near for the purpose of showing the requirements of practical forestry according to our definition of it. The form or outline of the tree, up to that period when thinning should be discontinued, should be conical or tapering, both in the stem and general form of the tree. After thinning is discontinued the shape of the tree alters, both in the stem and branches; the latter wither and fall off till only the top is covered, and the former gradually changes from a cone to a

cylinder. The cause of the latter change is partly due to the increase of woody deposit near to the live branches, and decrease of it where the branches have withered and fallen off. During this stage of growth, on dissecting a tree, it is found that the zones of wood near the vital branches of pine and hardwood trees are much thicker than at a distance from them, and the further distant the thinner they are. Every possible effort should be made in the thinning of plantations to preserve the proper quantity of live branches upon each individual tree, for if once the vitality is destroyed, the best future skill will be powerless in restoring it. Another reason for early thinning is in order not at any time to check the growth of the trees; for it must always be borne in mind that the immediate direct effect of thinning is to check the growth of standing trees, and this is done in at least two different ways.

It is very consoling to be told that if thinning is done gently, no evils will result from it. The most gentle mode of thinning that can be practised, is to cut down the one tree that stands too close to another. If many such trees are cut the thinning may be termed severe; and if only a few are cut, it may be termed gentle or light thinning. With words and terms, however, others may do as they please, but with us, from the sad effects produced upon the standing tree, we have something more to say, and some inquiries to make. When two trees have grown up side by side for many, or it may be only a few years, they have formed such an affinity for each other that separation becomes a painful and dangerous ordeal, so far as trees can be imagined to sympathise with or feel for each other.

Whether trees are affected through feelings or not

is of but little importance, since it is certain they are influenced in other ways—namely, mechanically and chemically. That thinning injuriously affects trees both ways there is little or no doubt; and we shall first see how they are injured mechanically. When two trees grow near each other, the branches on the confronting sides are less developed than on the opposite sides, and the roots underneath are developed in a corresponding manner; and if one of the trees is removed by thinning, the whole of the weak side of the remaining tree is exposed suddenly, and the wind acting upon it strains the tender and weak roots to such an extent as often to uproot the tree altogether. But apart from actually uprooting and blowing over the tree, the roots are strained and fractured so severely that they lose their vitality. Any injury inflicted upon resinous trees especially, whether upon branch, stem, or root, is succeeded by an accumulation of resin; and this, when it occurs extensively to the roots, is fatal to them, as it obstructs the sap-vessels and stops the circulation.

From observing the sickly aspect of a very extensive plantation after being thinned, and being called upon to assign a cause for it, which I was at the time quite unable to do, I afterwards turned my attention exclusively to the subject, and, after much labour, concluded I had solved the problem. The plantation consisted principally of Scots pine, with a small mixture of larch, spruce, and some hardwoods.

All species of trees did not present the same sickly appearance, nor did the same species on all the different situations and soils of the plantation.

The Scots pine was, of all others, the most sickly, especially upon the hard gravelly soils, and the larch

least affected of any. Of all forest-trees, the Scots pine is the most impatient of any artificial interference, and suffers more from thinning than any other species. In this case, after thinning, the trees lost their natural dark-green colour, and assumed a faint light-green. The leaves became shorter, and presented a clustered appearance. Some foresters, on giving their opinion upon the plantation, said it required more thinning—that the crop was too great for the poor gravelly soil. Some thought it blighted by some atmospheric influence; and others said it had come to maturity, and ought to be cut down as having attained it.

After weighing all arguments, and duly examining the whole case, I came to the conclusion that *thinning*, and *thinning alone*, had done the *mischief*. From a very wonderful provision in nature, the branches of a tree are so spread out as to shade the surface of the ground underneath where the delicate tender roots are spread, and thus keep them uniformly moist and cool, and never at any time scorched or unduly heated by the direct rays of the sun. A plantation, therefore, like that under consideration, which had grown up till about forty years old without ever receiving a regular thinning, may well be understood to have so far adapted itself to its circumstances of life as to be seriously and injuriously affected by any change such as thinning would produce. The trees—including stem, branch, and root—were what may be termed acclimatised, or rather habituated, and therefore thinning produced a severe change upon them equivalent to removal to a different inferior soil and climate.

There is much said about acclimatising of plants, which applies only to that part above ground, but there is little or nothing said about the roots of the

plants, although the latter are equally as important to the tree as the former.

Now, if a pine or fir plantation such as this, grown upon a dry gravelly soil, with the roots extended and ramified all over, and within an inch or so of the surface, it is neither unreasonable nor unlikely that, when a sudden opening is made amongst the trees by cutting one or more, and letting in a stream of sunny rays to heat or scorch the delicate, sensitive roots, so long nursed, protected, and shaded under a canopy of branches,—is it strange, we might well ask, that a change should take place with the roots of the trees, or that the heat of the sun should crystallise the fluids in the roots, and stop the flow of sap which was wont to nourish the tree? To this chemical change in *the roots* I attribute the sickly appearance referred to.

Another Scots fir plantation was thinned at about thirty-five years' growth, which had not been thinned during the preceding fifteen years. After thinning, it became sickly and death-like, and but for the important place it occupied in the landscape, would in all likelihood have been cut down. It, however, was allowed to stand, and after the fourth or fifth year began to assume its natural colour, and is now in an excellent state of health.

After a few years the trees generally recover, as the result of having made new roots suited to their new condition of life; but while some recover, others go back and perish.

From the foregoing results it must appear obvious that thinning is a very delicate and precarious operation, and is attended with much danger and risk to a crop of trees. If thinning could be entirely dispensed with, so much the better; and in the case of natural

forests, where no artificial thinning has ever taken place, there are to be found many hundreds of acres of wood which no artificial forest or plantation can surpass or even compare with in point of value. Any one who has examined the forests on Deeside, on Balmoral, Invercauld, and Mar estates, or Rothiemurchus, Glenmore, and Abernethy, on Speyside, and many others both at home and abroad, will support that testimony. A few acres on Rothiemurchus estate is worthy of special notice. When we examined it twenty years ago, the trees stood on an average 9 feet apart—some of them as wide as 15 feet, and others as close as 2 feet. The market value of it per acre at the time we saw it, allowing the trees to be all sound, was worth at least £300 per acre. The ground itself is the poorest possible—a light sandy gravel, with a crisp dry herbage of heath and moss, certainly not worth over 1s. 6d. per acre per annum for grazing purposes.

The question here arises, How are plantations to be managed that have been so thickly planted as to require thinning to prevent the trees from growing up disproportionately small? The answer is, thin early enough, and complete the operation before the side branches touch each other, and before any of them decay. This is advisable, not only for the preservation of the branches themselves, but in order that no unfavourable change be produced upon the roots of the trees, by admitting a degree of heat and air amongst them to which they have not been accustomed, and which they cannot endure without much privation.

In all forest operations by far too little attention is paid to the roots of the trees. They are often planted

in soil so saturated with water that no air can penetrate it and reach the rootlets—hence the lingering and sickly state the trees remain in for years after being planted; and it is only after they grow to such a height, when the action of the wind shakes and loosens the soil, that they begin to grow freely.

Having thus laid down some general rules and principles for thinning pine and fir plantations, and indicated how the work generally should be performed, I shall now make some observations upon the serious injuries inflicted by improper thinning, how these are produced, and how to avoid them.

Thinning, admittedly, should be done gradually, cautiously, and gently; but what, in the opinion of one man, constitutes gradual, cautious, and gentle thinning, is a very different thing in the opinion of another.

Gradual thinning, as generally understood, is the practice of thinning by degrees, according as the plantation advances in growth and requires it; cautious thinning means the practice of cutting few instead of many trees at one operation; gentle thinning signifies a little exposure at one time of each individual tree thus influenced, hence gentle exposure of the whole crop.

Words and phrases are, however, as yet but an imperfect medium of conveying what is meant regarding thinning, and must not therefore be too implicitly relied upon where such important consequences are involved.

The first most important case of injurious thinning that came under our own observation was in the Highlands of Scotland. The plantation was an extensive one, comprising about 1600 acres, and com-

posed principally of Scots pine. The soil was dry and of a gravelly nature, and the herbage chiefly heath and dry moss. No regular or systematic thinning had ever been performed, although a considerable number of trees had been cut out from time to time. When about thirty-six years planted, a regular and systematic course of thinning was entered upon, and continued for a period of about ten years. As thinning was continued from year to year, it was observed that the plantation, viewed at a distance, presented a light-green sickly appearance, and on near approach the pins or leaves were seen to be unusually short, and of a clustered habit of growth.

In consequence of the large percentage of deaths that annually occurred, the plantation was gone over once in about two years, and all dead trees cut out. The percentage of deaths, however, so greatly multiplied year by year as to become alarming, and awoke the inquiry, "What is to be done?" As the true cause of the disease, however, was never *once* suspected, no wonder the antidote was withheld. The subject became one of general interest, and many prescriptions were given for the malady. Some thought the ground too dry, while others considered it too wet. Some thought the plantation should be depastured with cattle, instead of sheep, which were grazing it; while others thought all animals should be kept out of it, and the herbage allowed to grow up luxuriantly. Like others, I was not aware at the time of the cause of the sickly state of the plantation, nor did I understand it fully for several years afterwards.

That thinning was the inducing cause of the sickly state of the plantation I have now not the least

doubt, and the following observations strongly confirm it. One small portion of a few acres was not thinned in consequence of being somewhat detached, and this portion was in no way affected, the trees always remaining of their natural dark-green colour, and the foliage rich and good. The manner in which I consider thinning to be injurious in this case, is by allowing the rays of the sun to heat and dry up the ground. By a wise providence the branches of a tree are so spread out on every side as to shade and keep the roots cool and at an equal temperature; and when, as in the act of cutting down a tree, the shade is removed, the rays of the sun penetrate the soil, and unduly heat it to a serious and often fatal extent. The extremities of the roots, probably in every case, extend beyond the spread of the branches, and are thus unshaded; but in the case of pine and fir—and indeed all true plantations—it may be said that each tree also shades the roots of its neighbour as well as its own, and therefore, when cut down, they are equally exposed and injured as if each only shaded itself.

Thinning is not equally injurious to all species of trees, nor is it equally hurtful on all descriptions of soils. Where I have always witnessed the worst results, is upon Scots pine growing upon a dry gravelly soil, bare of herbage. This also accounts for the different results produced upon the growth of plantations by depasturing them. When the soil is inclined to wetness, and the herbage luxuriant, grazing with sheep or light cattle is advantageous for the trees; while, on the other hand, if the ground is dry, inclining to gravel, and the herbage bare, eating the grass or heather is less or more injurious. I have

always observed that pine plantations upon dry gravelly soils assume a light colour after being thinned, and only by slow degrees regain their natural dark-green shade, till another thinning takes place. The annual layers also indicate a corresponding falling off in growth, which is usually greatest the second or third year after the operation has taken place. In very young plantations the injuries are much less observable than in older ones, and less upon larch and spruce than upon Scots pine and silver firs.

Thinning is also injurious in another way—namely, by throwing an unusual and unnatural strain upon the roots of the trees which were formerly protected. The strain is often so severe that the tissues are fractured, and the tree blows over by the first gale; but even far short of this, much injury is inflicted, especially on conifers, whose juices, on receiving the least injury, crystallise, and thus obstruct the flow of sap during the future life of the tree.

The only practical remedy for plantations injured by thinning as above indicated, is to encourage undergrowth, and even scatter branches over the surface of the ground.

It may appear to some a bold and gratuitous question to ask whether thinning, after all, has not done more harm than good. There is no manner of doubt, however, that it has done, and is still doing, a very considerable amount of harm—not because thinning is of itself an evil, but because it is done at the wrong time and in the wrong way.

CHAPTER VII.

EFFECTS OF THINNING ON YOUNG PLANTATIONS.

THE following is the system of thinning practised by us, and which, after a trial of many years upon an extensive scale, we find attended with such favourable results as to inspire us with every confidence in recommending it.

No. 1 is an enclosure of 500 acres, and between six and twelve years planted—the youngest part six, and the oldest twelve. It is situated between 500 and 800 feet above the level of the sea, and covers both sides and top of the hill, which extends north and south. The exposure is severe on all sides, but more so on the north and east, which slopes towards the sea, which is distant about four miles. On that side all evergreens, including the Scots pine, are seriously injured by the winter blasts.

The plants are composed of Scots pine, larch, and a slight mixture of Norway spruce and silver fir.

The natural herbage consists of heath, some parts whins, with a mixture of those grasses indigenous to moor soils.

The ground was all well drained previous to planting, and all well fenced, partly with turf dykes, partly with wire fences, and partly with wooden paling.

In consequence of the long interval between commencing to plant and finishing it, difference of quality of soil and exposure, &c., there is a corresponding difference in growth all over the plantation. In some parts the trees are over 15 feet high, while in others they are scarcely half that height.

With such an extent of plantation before us, we had to consider well what course to pursue with the thinning. We saw that to allow such an extensive plantation to grow to any considerable height before thinning would be attended with disastrous consequences, and in order to avoid this, we commenced work on all parts where the trees had attained 6 to 8 feet high, and cleared openings or shooting-roads as the work proceeded. The roads are laid off 100 yards apart each way, thus dividing the whole plantation into squares containing 10,000 square yards each. The roading was done by contract, the width specified to be 16 feet, and all trees, heath, and whins cleared off and thrown clear of the side-drains at least 3 feet; the trees, heath, and whins all to be kept separate, and laid in small heaps amongst the growing trees in such a manner as not to injure them. The trees and whins to be cut level with the natural surface of the ground, and all heath and other herbage to be mown with the whin scythe and raked off.

The work of roading was let in two separate contracts. By the one the work was done at three-farthings per lineal yard, and by the other at one penny per yard. At the above rates the contractors earned for themselves, and those working under them, fair wages, say 18s. to 20s. per week. The heath, whins, and thinnings were sought after by the tenant-farmers and peasantry in the district, and carted off by them with-

out charge. Having first determined upon the base-line as the starting-point, the whole subsequent operations of roading were carried on by means of the cross-staff and poles used in land-measuring. In the midst of a dense forest or large plantation like this, it is impossible to carry the lines straight and parallel without some squaring instrument, of which the cross-staff is the most convenient for practical use amongst common labourers. The reason why it is desirable to have the roading done before thinning is commenced, is in order to guide the latter operation. Any one practically acquainted with thinning young plantations, knows the unpleasant effects of a bewildering and interminable thicket, and the confinement and want of air and light. I conclude that ten men do as much work in one month, in a well-roaded and properly laid-off plantation, as they would do in six weeks in one without such roads or openings. Another reason for making the roads the first work in connection with thinning is to afford facilities to the keepers for killing rabbits and game. I recommend making all the roads straight and parallel with each other, as far at least as the nature of the ground will admit. The advantages of the parallel straight roads are also experienced during the cover-shooting, by affording the beaters the opportunity of coming into line at the end of every 100 yards; and the roads themselves determine the distances at which the guns are to be placed. Straight and parallel lines of roads, though recommended, cannot always be carried out in practice. Roads leading up-hill must, of course, be winding or serpentine; and as no road can be led through a morass or swamp, or over a precipice, all such places must be avoided, and this cannot be done

without deranging the plan of squares and straight lines. My plan is, when a deviation of road is unavoidable, to confine it to the one particular road, and not derange the general lines of all the others.

The work of thinning is proceeded with according to the size of the trees, and here special attention should be paid to their height. As a rule, I thin when the remaining crop stands 6 or 8 feet high, at which period they should be thinned to about 7 feet apart, or say 800 trees per acre. I know this practice is called in question by some and condemned by others, and few approve or practise it.

On these and other accounts, I am all the more anxious to state fully my own reasons for adopting it, and giving my experience of it upon an extensive scale.

First, an active man with a proper hand-bill (not hedge-bill), which is the only proper implement I know of for such work, will thin an acre in two days, and this represents 6s. per acre added to the original cost of forming the plantation. The thinnings at this stage I put no money value upon. They are mostly collected and carted away by the tenantry and others; but the cost and labour of clearing are so great, that no money is charged for them except a very small sum for such as are on the margin of the plantation and convenient to clear.

The second reason for thinning at this early period is in order to give the remaining crop perfect freedom and liberty to develop their lower branches. It is those branches situated upon the lower part of the tree that supplies food and nourishment to the roots, and unless they are preserved vital at this critical period of the tree's existence, it very soon ceases to

develop itself and make wood properly; in fact, it ceases to grow to anything like satisfaction at that very period when it should be making wood faster than at any other period of its history. If only it could be borne in mind that the loss of every lower branch of a young tree is just a corresponding loss of roots, and as the branches suffer so do the roots,—if so kept in mind and practised, it would be a good and profitable thing for every one interested in woodland property.

To the preservation of the lower branches of the celebrated larch forests of the Duke of Athole (more than anything else) may be attributed their successful growth. The Duke's larch forests were instructed to be planted 6 feet apart, and that distance, assuming that all the trees grew, allowed all the lower branches to grow 3 feet in length before being checked; but as numbers of them would no doubt decay early, others from accidents and other causes perish, many of the trees would thereby produce their lower branches twice that length,—hence the splendid results of the growth of the larch in these forests.

Having witnessed so much injury inflicted upon young plantations, and some entirely ruined, by the lower branches being interfered with when too young, we would recommend, in the strongest possible terms, the special attention of all who have the management of plantations to this all-important aspect of the subject of thinning.

Many plantations under thirty years old may be benefited by thinning if the trees have only sufficient branches; but where they have stood so closely together as to have destroyed each other's vitality to two-thirds their entire height, all hope of restoring

them is at an end; and if any thinning is done in such cases, it does not improve but rather injures the crop, by retarding its growth in various ways, as already explained.

All thinning of pine and fir plantations, I would again repeat, should be commenced before the side branches touch each other, and be continued till the trees stand about 7 feet apart, after which they may very safely be handed over to nature to perfect and complete their growth,—the forester meanwhile only to be employed in cutting and removing dead or sickly trees till the crop is ripe, when it should be cut, cleared, and the ground replanted.

CHAPTER VIII.

EFFECTS OF THINNING ON ADVANCED HARDWOOD PLANTATIONS.

No. 1 is an extensive hardwood plantation on Cullen estate, which had never been thinned up to twenty-five years old. It consists of oak, ash, elm, beech, sycamore, lime, &c. At the age of twenty-five it received a moderate thinning, and from that time to the present (twenty-five years) it has received every possible attention. Some of the trees are over 1 foot diameter, but the greater part are not over 6 inches, and some not even so much. The soil is good, chiefly of a loamy nature, and of a good depth, but somewhat damp.

The remarkable disparity of growth amongst the trees impresses one with a desire of knowing the reason why some are so comparatively large and others so very small, being all of the same age and grown on the same soil. The explanation is simply this: Those that were confined, and thereby deprived of their lower branches, are the small ones, while those that had room are large.

It is a common impression that hardwood trees, though denuded of their branches when young, will recover them after being thinned. That such is not

the case we have ample proof; for here there are hundreds of trees as bare as poles, with only a tuft of branches on the top, which have had ample room for over twenty years to develop their side branches, had it been in the order of nature to do so. Some trees —as the oak—do make a strenuous effort to reproduce their lateral branches; but when the effort at all succeeds, it is by spray emanating from the stem, and not the development of the existing branches, which rather degenerate than enlarge, so that what is gained of growth on the one hand is more than lost on the other. It is very difficult to know how to treat a plantation successfully that has once been seriously neglected in thinning. Cutting down and allowing a new crop to grow from the stools is sometimes recommended; but this plan is attended with at least one very serious objection—namely, the circumstance that the scion springing from an old stool produces a tree in character, form, and habit exactly the same as that from which it springs. A dwarfed and stunted tree reproduces dwarfed and stunted trees, crooked and deformed ones the same, like reproducing like all through,—a circumstance which, though of the greatest consequence, most foresters have never given any attention to.

Unless trees are quite sound and healthy, no lateral satisfactory growth will ever take place by thinning. There is something, also, very remarkable about certain tree-roots in the manner in which they remain vital after being severed from the stem. I know several old stools still vital from which the trees had been cut more than thirty years previous. How they continue vital year after year and yet produce no shoots has hitherto been quite a mystery, but appears

now solved by the discovery that the roots of such stools have become grafted to other roots of growing trees in the neighbourhood, termed subterraneous grafting.

"The most valuable crop of oak timber I ever saw," says Mr J. Stinning, an extensive timber merchant in Sussex, "was upon the Duke of Devonshire's property in Devonshire, where the trees stood from 6 to 8 feet apart." The best we ever saw was a few acres of natural Scots pine forest on Rothiemurchus estate, Strathspey, where the trees stood from 2 to 15 feet apart, and a few groups of oak on the estate of Pensrock in Sussex, on which estate we saw 100 trees sold by auction for £800.

CHAPTER IX.

THINNING MIXED PLANTATIONS.

THE late Mr Robert E. Brown, son of the late Dr James Brown, author of 'The Forester,' says: "I have found that as a rule woods may be calculated to pay a proprietor at the end of fifty years fully three times the amount which would have been received from the same ground had it been left as pasture or any other agricultural purpose; and in order to illustrate this, I shall give a few examples of what I have taken from plantations at their different ages:—

	Rate per tree. s.	d.	£	s.	d.
On the estate of D——, in Scotland, I take a first thinning, at twelve years old, from one acre of mixed larch and Scots pine,	0	0½	1	9	2
Second thinning, at sixteen years old, 500 trees, ...	0	2	4	3	4
Third thinning, at twenty years old, 370 trees, ...	0	6	9	5	0
Fourth thinning, at twenty-five years old, 300 trees, ...	1	2	17	10	0
Fifth thinning, at thirty years old, 250 trees, ...	2	4	29	3	4
Sixth thinning, at thirty-five years old, 160 trees, ...	3	0	24	0	0
Seventh thinning, at forty years old, 120 trees, ...	4	0	24	0	0
Carry forward, . .			£109	10	10

Brought forward,	. .		£109 10 10
Eighth thinning, at forty-five years old, 80 trees,	4 2		16 13 4
			£126 4 2
Deduct from the above the expenses of management and general maintenance,		£31 5 0	
Deduct original expenses of planting,		3 0 0	
			34 5 0
			£91 19 2
Value of standing crop, at fifty years old, 108 trees, at 6s.,			32 8 0
			£124 7 2

"In the neighbourhood of these plantations there was land of a similar description to that on which the trees were growing, and which was let as sheep-pasture at 10s. per acre. This, therefore, shows that the land under pasture gave the proprietors £25 in fifty years; while under a crop of larch and Scots pine it gave £124, 7s. 2d. per acre in the same time, or a rental of £2, 10s. per acre fully.

"The following statement shows the value which may be received from a mixed hardwood plantation in the north of England at fifty years old, and is taken from the thinnings which I have removed from various woods upon five different estates.

"The plantations consisted of a mixture of oak, ash, elm, and sycamore.

	Rate per tree. s. d.	£ s. d.
First thinning, at ten years old, I have generally taken 600 trees per acre at	0 1	2 10 0
Second thinning, at fifteen years old, 500 trees per acre,	0 2½	5 4 2
Third thinning, at twenty years old, 450 trees per acre,	0 5	9 7 6
Carry forward,	. .	£17 1 8

Brought forward, . . .				£17 1 8
Fourth thinning, at twenty-five years old, 400 trees per acre, ...	0	8		13 6 8
Fifth thinning, at thirty years old, 250 trees per acre, ...	1	6		18 15 0
Sixth thinning, at thirty-five years old, 180 trees per acre, ...	3	0		27 0 0
Seventh thinning, at forty years old, 80 trees per acre, ...	10	0		40 0 0
Eighth thinning, at forty-five years old, 40 trees per acre, ...	24	0		48 0 0
Value of standing crop when fifty years old, 90 trees per acre, ...	30	0		135 0 0
				£299 3 4
Deduct from this expenses of management and general maintenance for one acre in fifty years, . .				60 0 0
				£239 3 4
Also deduct the expenses of the first planting, at per acre, ...				5 5 0
				£233 18 4

"On an average the rent of the lands on which these plantations are growing, if they were under pasture, would be about 15s. per acre, judging from similar land in the same districts where plantations are. This will give a sum of £37, 10s. for the fifty years. I have shown that the same kind of land, under a crop of mixed hardwood trees, will give a sum of £233, 18s. 4d. in fifty years, or a net annual income of rather more than £4, 10s. per acre. And it must be borne in mind that these plantations to which I refer never had been regularly under any defined system of management. If they had been under a regular systematic course of forestry, they would have given a much higher income annually.

"Five years ago I received the management of about 400 acres of plantations on the estate of Wass in the north of England. At that time I found

them to consist of a crop of mixed oak, ash, elm, sycamore, birch, and maple, grown from old roots from twenty to thirty years old. They were in a very unsatisfactory condition, and had been allowed to grow for twenty years without receiving any thinning of any consequence. Thinning, certainly, had been attempted in some places near to good roads, when a few trees were wanted for estate purposes; but these thinnings had in almost every case been overdone. The estate was owned by a thoroughly enlightened gentleman, who knows how, when, and where a thing should be done, and who was anxious to have the woods put into good condition. During these last five years we have endeavoured to improve the woods properly, and the result is the improvement of the plantations to an amount fully twice the value they were at first, after taking from them a regular income, in the shape of thinnings, every year. These plantations have been giving an average yearly income since 1861 of £2, 10s. per acre net, and similar land on the estate is let with difficulty at 10s. per acre.

"One instance, in particular, will show the increase of value of woods when under a regular course of thinning. A wood, consisting of a crop of oak and ash, extending to 100 acres, was valued in 1864 by several foresters and timber merchants at £4000; since then thinnings have been taken from it to the amount of nearly £2000, and in the present year (1866) I am offered £5000 for the standing crop.

"I consider thinnings of very little value before the plantation reaches the age of fifteen years—all that is required up to this time is a careful going over, cutting out any dead wood, and relieving any healthy tree that requires it. I believe that most of our woods at the

present day are ruined by overthinning—the result, first, of the want of trained men; or second, where experienced men are employed on an estate, the term of their management is so uncertain that they aim more at having a good balance in their favour at the end of the year than securing the ultimate success of the plantation. I strongly recommend that no healthy tree be cut until it has attained a marketable value. The great aim of forestry should be to secure the highest possible return from the ground, and nothing adds more to this than length of scantling. Length is the principal object, and can only be attained by preserving a closeness of trees on the acre. When I say a closeness of trees, I do not mean that one tree should interfere with another, knowing that the two things most essential to the growth of trees are root and branches. Quality, nowadays, is subordinate to quantity, and there is a danger of placing too high an estimate on the value of thinnings and too little on the crop remaining for the final cutting. The final cutting should never be less than eighty trees per acre if larch, and nearly two-thirds more if Scots fir."

"Supposing that 2500 larches and 1500 Scots firs have been planted per acre, the thinnings might realise as follows :—

First thinning, at fifteen years—				
Larches, 600, at 2d.,		£5	0	0
Scots, 300, at 1d.,		1	5	0
	900	£6	5	0
Cost of cutting, 3s. 6d. per 100,		1	11	6
		£4	13	6
Second thinning, at eighteen years—				
Larches, 300, at 3d.,		£3	15	0
Scots, 200, at 2d.,		1	13	4
	500	£5	8	4
Cost of cutting, 4s. per 100,		1	0	0
		£4	8	4

Third thinning, at twenty-two years—			
Larches, 500, at 6d., ...	£12	10	0
Scots, 300, at 3d., ...	3	15	0
800	£16	5	0
Cost of cutting, 6s. 6d. per 100, ...	2	12	0
	£13	13	0
Fourth thinning, at twenty-six years—			
Larches, 500, at 1s., ...	£25	0	0
Scots, 200, at 6d., ...	5	0	0
700	£30	0	0
Cost of cutting, 8s. per 100, ...	2	16	0
	£27	4	0

Which gives for the four thinnings an expenditure of £7, 19s. 6d., and an income of £57, 18s. 4d. There will remain 600 larches and 500 Scots firs, or 1100 trees; but allowing for 300 failures and removals during the first fifteen years, there are still 800 per acre." This is the number of trees I begin with as the real crop to operate upon, which I consider very near the right quantity.

Tree-planting as an Investment in Ireland. By Wm. Harrower, Tipperary.

"We have now," says Mr William Harrower, "to determine what is to remain for the final cutting. If the larches are growing well they should be left, and if not, the Scots firs. The whole should be cut between thirty-five and forty years of age. My first reason for cutting at an early age is, that the timber trade of Ireland differs entirely from that of England or Scotland. There is not a great demand for home consumption, and we must export. Secondly, the price of timber does not rise in a corresponding degree with size. It is nearly impossible to find a market for heavy Scots fir, even of the best quality. There are some very fine Scots firs in the south of Ireland. Timber suitable for pit-props commands the readiest market and the most remunerative price. Larch containing about 20 cubic feet finds a ready

market, and if grown on suitable soil and skilfully managed, should reach that size at forty years; and the plantation should contain 200 to 250 trees per acre, according to their vigour. I would estimate the crop at this age for final cutting at about 600 trees per acre, if thinned early enough. Thirdly, by cutting at an early age the planter may realise some of the money that he expended. At the present day proprietors have large quantities of good timber standing and realising nothing, the felling of which would destroy the appearance of their estates. I see nothing to keep us from being able to grow timber, so that we could always have some to cut. As to France being able to supply the British demand, I do not see how it can. Except Norway, Sweden, and Russia, no European State has a surplus supply of timber; therefore I see no cause for alarm on that score. I am aware we import handsome spars from France and Germany. Why is this? Simply because they do not thin their woods until each tree is very tall. They grow a great number per acre, while we cut away just what they cultivate. I have now given sufficient reasons for felling at an early age. To come to the final cutting. Estimating the next thinning and final cutting at the same sum as the previous thinnings, gives a total of £115, 16s. 8d.; allowing the same expenditure for cutting, &c., and taking thirty-five years as the average age of the final cut, the outlay will be, viz.:—

Planting and enclosing,	£8	10	0
Thinning, &c.,	7	19	6
Final cut,	7	19	6
	£24	9	0

An income of £115, 16s. 8d., after deducting all expenditure, will leave £2, 12s. 5d. per acre per annum. I am not a believer in great things; but on this estate three years ago the final cutting of one acre of larch yielded 160 tons, at £1 per ton. The plantation was forty years of age, and had been thinned from time to time for fencing purposes only. The value of the same land let to a farmer would have been 35s. per acre per annum, which shows that the timber paid well, being upwards of £3 per annum after deducting expenses. Two years ago, on a neighbouring estate, a large plantation realised £1, 15s. per acre per annum. This plantation would have realised more per acre, but parts had been cut before. No tree is so valuable as larch in its fertilising effects, from the richness of the foliage it sheds annually. I have no hesitation in planting larch—have seen a great many cases where it is succeeding to perfection; therefore I see no reason why we should not be able to grow timber profitably here, as well as they do in France or Germany. My belief is that timber will increase in price, and so answer the question, Will it pay to plant?"

In my report to the Highland Society of Scotland, 1868, the following statements are made, which I adhere to without alteration:—

No. 1 is a mixed plantation, situated in the south of the county of Roxburgh, thirty-two to thirty-six years planted at date of report. The ground, previous to being planted, was used as a grazing for cows, and was much esteemed for that purpose; but in consequence of its precipitous nature, it was considered impracticable to cultivate, some parts being

so steep as to render it unsafe even for the grazing of cattle.

The plantation is situated at an altitude of between 250 and 350 feet above the level of the sea, and is sheltered, with the exception of the highest ridge, from the north and west winds by higher grounds, so essential to the growth of all trees, particularly larch and spruce.

The trees of which the plantation is composed are embraced in the following list:—

Oak to constitute the principal ultimate crop.

Ash to be thinned out from amongst the oaks as the last thinnings.

Elm to be thinned out from amongst the oaks as the last thinnings.

Sweet chestnut to be thinned out from amongst the oaks as the last thinnings.

Larch to be thinned out as first profitable thinnings, after having acted towards the hardwoods as nurses.

Scots pines to be thinned out as secondary thinnings, after acting to the hardwoods as nurses.

Spruce, a few to remain permanently to impart variety to the plantation, and act as nurses to the hardwoods; the others to be thinned out for profit.

The preceding list comprises seven different sorts of trees, in addition to which four other varieties were planted, of which only a few specimens remain. Such a great variety naturally suggests the inquiry, Why plant so many sorts? The answer is, that at the time of planting it was not known which class of trees would succeed best; and therefore a great variety was

planted, with the view of thinning out those that did not succeed—a practice which, though fast becoming obsolete, is still adhered to by some planters. The plantation, at the time the writer became acquainted with it, had been several times thinned. The stools upon the ground indicated that it had been planted at distances from 3½ to 4 feet apart, the hardwoods at 9 feet to 12 feet apart, and filled in with pine and firs to the former distances.

The first thinning was performed when between twelve and fifteen years planted, at which age, owing to the sheltered and otherwise favourable situation, the trees were considerably too much drawn up—an evil probably little thought of at the time, but the effects of which can never be counteracted.

In the operation of thinning, the work has always been performed with axes, and in doing so great attention has always been paid to keep the stools low, generally quite level with the surface of the ground, —a system which, in thinning young plantations, is highly commendable for neatness and future comfort in travelling through the plantations and clearing the wood. By this means also coppice-wood is almost entirely prevented from springing up after the hardwoods are cut, which in this case was considered desirable. In thinning out the spruces at an early age, some were cut over at from 3 to 4 feet above the ground, which caused them to assume the habit of beautiful shrubs, and form a cover for game which cannot well be surpassed.

So long as the trees were small, and could be cut and felled by one man in the proper place, axe work was certainly, if not the cheapest, at least the best method of thinning. But from the time the trees are

9 inches diameter at bottom, they are more economically cut by means of the saw, hook, and rope (see fig. 5). This, though a very simple and unimportant-like implement, is yet as useful and economical as any other used in forestry. It consists of three parts—viz., *A*, the hook, which is made of inch-round malleable iron, with a ring to attach a strong rope to, and socket into which to put the sharp end of the pole to put the hook round the tree immediately above a branch; and there it remains hanging till the tree is nearly cut through, when the rope *B* is taken hold of by one of the two men, who usually work in pairs at such thinning, and draws the tree into its proper place, so as not to injure any of the standing trees. The pole *C*, it will be observed, is not in any way fastened to the socket, but simply slipped in to hoist the hook, when it is withdrawn and removed out of the way till again required. The rope, if sound, does not require to be heavy, and the pole, which is usually about 12 feet long, should be about the same thickness as that of the handle of the pruning-chisel—viz., $1\frac{1}{2}$ inch diameter, and of light, sound, redwood pine.

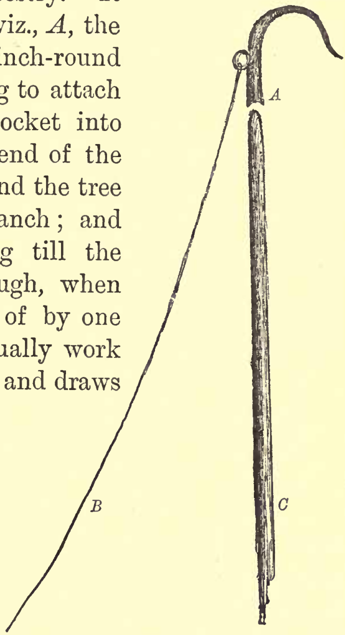

Fig. 5.

The mode of thinning mixed hardwood plantations is always attended with greater difficulties than that of

thinning plantations of one species of trees; hence the great expense always entailed in doing so, and consequently the small returns. In thinning out a larch-tree, for example, growing in the midst of hardwoods, where an open fall cannot be obtained, it is necessary to ascend the tree either by means of a light ladder or otherwise, and the operator being provided with a handsaw, to commence, as he ascends, and clear the tree of all such branches as are likely to come in contact (when falling) with the standing trees.

Frequently the whole of the branches, and sometimes also the top part of the tree, have to be cut off in this manner; and the trunk thus pollarded is, by means of the pole and rope attached, drawn down into the most convenient open space. It frequently happens that a tree thus situated and taken down costs considerably more than its worth in the market. Such was found to be the case in thinning this plantation. The cost of labour was frequently more than double the value of the thinnings; and never in any instance during the writer's experience has the produce of those thinnings equalled, or even approached, the cost of the labour.

Before commencing to thin, the trees were always marked by the head forester, so that the best skill was brought to bear upon the operations, and the work performed in the most judicious manner. At first the thinning was performed at all seasons, but of late years it was principally done during the summer, at which season the bark was stripped from the oak and larch. The chief difficulty of thinning at this season of the year is owing to the tenderness of the young shoots, particularly of those upon the pines and firs. Spruce are so tender and easily injured at this period of the year, that a slight shake of the tree is

sufficient to break off the leading top, and so disfigure the tree ever afterwards.

In consequence of no separate account having been kept of the expenses or returns from this plantation alone, it is impossible to give an exact statement of such; but from notes taken during several thinnings, the labour exceeded the value by about 25 per cent. This arose partly from the difficulty of felling the firs and pines amongst the hardwoods, so as not to injure the latter, partly from all the work having been done at day-wages instead of by the piece, and partly from the difficulty of clearing the ground of the wood and branches, which had to be removed at great expense, and for which no proper market could be found. Add to this the more frequent thinning which mixed plantations require, in consequence of the great difficulty of keeping the nurses at a proper distance from the hardwoods, and also the greater urgency of pruning, from the trees becoming almost invariably defective of branches on one side, while the growth is superabundant upon the other.

The following statement shows the average actual crop upon the ground in 1864, and represents the market price per acre of the whole at that period:—

Species of Trees.	Number per Acre.	Value each.	Value per Acre.
		s. d.	*£ s. d.*
Larch, ...	10	7 0	3 10 0
Oaks, ...	76	1 6	5 14 0
Ashes, ...	12	2 0	1 4 0
Elms, ...	20	2 0	2 0 0
Spanish chestnuts, . .	12	2 0	1 4 0
Spruce, ...	10	5 6	2 15 0
Scots pine, ...	10	1 6	0 15 0
	150		£17 12 0

The above statement represents the crop and the market value nearly, standing, and is about what it was worth at the above date, if cut.

The various classes of trees are by no means regularly distributed over the ground; they are found closer in one part than in others, but average the above very nearly.

Ground similar to this plantation is letting for grazing purposes at from 15s. to 20s. per acre: the plantation, however, not being at a growth at which it can properly be valued as a marketable subject, no reliable statement can now be given to show the profit or loss of it.

The next statement shows the value per acre of the plantation, if, instead of being mixed as above, it were of one class of trees only, allowing them to stand at the same distance apart as they now do, but might easily have stood at half the distance if grouped.

Species of Trees.	Number per Acre.	Value each.		Value per Acre.		
		s.	*d.*	£	*s.*	*d.*
Larch, ...	150	7	0	52	10	0
Spruce, ...	"	5	6	41	5	0
Scots pine, ...	"	1	6	11	5	0
Oak, ...	"	2	0	15	0	0
Ash, ...	"	2	0	15	0	0
Elm, ...	"	2	0	15	0	0
Spanish chestnut, . .	"	2	0	15	0	0

The above statement, though showing the actual value per acre each class of trees would be, yet does not by any means show the value they might have been if the trees had been grown separately, or grouped; for while the larch and spruce, as individual trees, would not have attained quite the above value,

yet fully one-half more trees would have been upon the ground, while the hardwoods would not only have stood much closer together upon the ground, if grown unmixed, but would, on an average, have been of at least one-third more value per tree.

In consequence of the whole of the plantation never having been thinned regularly throughout at one time for many years, and of no actual account having been taken of the thinnings either before or after being cut, it is only from notes, taken at various times, that I have been enabled to arrive at the above conclusions, and which, from this plantation having always been regarded as a model one, I have thought it the more essential that I should be minute in the various matters of detail. A thinning of the plantation being done during the summer of 1864, an auction sale was called on 30th July, when the thinnings disposed of realised the following prices:—

Peeled oaks, per dozen, pit-prop size, . .	£0	12	0
Ash, per dozen, useful size, ...	1	4	0
Elm, " "	0	18	0
Larch, suitable for secondary general purposes, per dozen, ...	4	0	0
Spruce, do. do., ...	3	10	0
Scots pine, do. do., ...	1	0	0

Branches and burnwood from 1s. 6d. to 4s. 6d. per lot (each containing about one ton), according to access for loading, description of wood, &c.

It will be observed that the sums realised at the sale for some sorts of wood (as the oaks) are below the estimated value per acre; but this is accounted for by the latter being peeled. The value of the bark is about equal to one-third that of the trees as they stand.

The Scots pines suffered in many cases by the

larches dashing against and destroying their leaders, but the former were mostly thinned out at an early age. Those now remaining are coarsely grown, occasioned by the system of thinning and the nature of the soil; they are likely to become large trees, but of a soft, inferior quality.

The hardwoods are in general badly grown, especially upon the best soil and sheltered places; they are tall compared with their thickness, have few branches, thin bark, and badly rooted. Oaks of this age, having the same soil and situation, should have been at least, on an average, one-third more value, except upon a few spots where the soil is unsuitable. Most of the soil is suitable to the growth of ash, which thrives well, but, like the oak, is very deficient in branches, and in value only about two-thirds of what might have been expected.

This plantation is regarded by some as a model one, perfect almost in every respect, not even allowing that there is a deficiency of branches; while in the writer's opinion, at least one-third of the branches are wanting in one-half of the plantation, and one-fourth wanting in the other;—occasioned by over-much shelter—not over-crowding, as the term generally implies, which is a widely different thing—the plantation having always been kept with a number of trees per acre upon it below rather than above that of a fair crop; at same time, owing to the naturally sheltered situation, the damp nature of the soil and its clayey consistency, combined with the luxuriant summer herbage upon its surface, and the shading and sheltering effects of the pine and fir nurses, the unfavourable results described have been brought about.

One circumstance connected with this plantation

worthy of special notice is the regular systematic manner in which it has always been rather over than under thinned from first commencement up to 1868. In confirmation of this statement the writer would remark, that while in this case 150 trees constituted the crop per acre, a professional (forester), whose writings on tree-culture are well known, gives two instances of thinning like plantations of ages similar to this, the one having 365 trees upon an acre, and the other 390,—being in both cases more than double the number found in this one.

No. 2 is another plantation of a general mixture in the south of Roxburghshire, planted in 1850 and 1851, situated at an altitude of between 400 and 500 feet. It occupies part of a glen extending from north to south, the bottom of which is well sheltered from all points, and only the outskirts along the top of the banks are exposed; the length of the plantation is about 700 yards, by a mean width of about 130 yards, comprising an area of about 20 acres.

The trees of which the plantation is composed are larch, spruce, Scots pine, oak, ash, elm, and sycamore. The two former were planted to act as nurses to the three latter, as the ultimate crop, and the following statement is designed to show—

First, The evil effects of the mixing of different kinds of trees in plantations—such as the loss and damage occasioned thereby, the greater difficulty of management, the disadvantage at which the trees are grown, and the greater expense they entail.

In order to illustrate these results the writer would endeavour to draw attention to the following particulars, such as the great proportion of slow-growing trees sacrificed by those of rapid growth over-growing

them, so that they are cut down as mere weeds before they can possibly be of useful size, or if not cut down till of useful size, the loss is still greater, as in the present case. The extra labour of thinning and clearing the thinnings out of the plantation entailed expense almost incalculable, as will subsequently be shown.

The evil consequences of general mixing, in contrast with that of grouping, may be seen in this plantation. One part of it, a year younger than the other, was nearly all planted with larch, while the other part, as already shown, was of a general mixture. The soil, exposure, altitude, &c., are alike in both, yet the difference was altogether in favour of the part slightly mixed. The trees, by making allowance for the difference of age (one year), were scarcely so tall as the others, but were more proportionably grown and without any appearance of disease; while the larches in the general mixed part were all but exclusively diseased, being covered with ulcer.

In the general mixed part the bark of the larch is black, as if dusted over with soot: numerous larch aphis infest them all, and ulcer is upon most of them. The spring frosts of April 1859 browned the foliage of nearly all the larches in the plantation in both parts; but while those *partially* mixed with pine and spruce soon recovered without sustaining any visible hurt, the other part, or that *completely* mixed and overcrowded, was so severely injured that most of them lost their leader, while hundreds were quite killed. The difference of effect produced seems only to be accounted for on the ground that the one part being healthy and of vigorous growth, was able to ward off the injuries; while the other, being already

sickly, had no such efforts to expend to promote similar results.

The Scots pines are tall compared with their thickness, badly branched, of a dark colour in the bark, and mostly infested with insects; the spruces (except upon the soft ground) are slender, with few branches, and badly rooted; the hardwoods are nearly all deficient of side branches, which is to them the greatest of all wants—many of them bare on one side, while others are without a proper leader.

Secondly, To show that a general mixed crop of trees upon good soil such as this is more difficult to manage, more easily and permanently injured, than upon soil of inferior quality. This is owing partly to the powerful tendency of a rapid growth both in respect to root, trunk, and branch—the trees not having room to spread their branches, and roots are forced to a rapid upward growth, thus producing length without thickness in proportion. Thinning in such cases retards the growth without effecting the desired object of changing its direction, except to a very limited extent.

Thirdly, The proceeds arising from the first thinnings ought not to be an inducement to prolong the period of doing the work, seeing that the extra expense entailed in the performance of it more than absorbs the profit; while, at the same time, the trees are by such means so far injured in their growth as to be ever afterwards a second-rate crop. It cannot be too strongly recommended to thin the first time with only one object in view—namely, that of benefiting the future crop.

Fourthly, Although the operations of thinning were performed rather before than after the usual time for

doing such work, yet the mixing system has, in this instance, proved a considerable failure, demonstrating very clearly that a system of general mixing of trees is always attended with less success than that of judicious grouping, whenever the management requisite for each is strictly attended to.

On examination of the plantation previous to thinning, the following were about the general proportions and distribution of the trees upon the ground per acre :—

Hardwoods of sorts,	500
Larch,	1000
Spruce,	700
Scots pines,	800
	3000

The work of first thinning was performed in September 1858, beginning the operations by marking all the live trees to be taken out, and giving instructions to the workmen to cut all decayed ones, which saved the labour of marking. The cutting was performed by eight men and a boy; the foreman in direct charge of the work wrought also as one of the men, being chiefly engaged marking immediately before them, or pruning close behind them. In consequence of the smallness of the trees, and their closeness together, considerable difficulty was experienced in using the axes. The *hand-bill* (fig. 3, page 145), therefore, was used instead—an instrument which, when properly made, and in the hand of an experienced workman, is much superior to axes for thinning small wood. To prevent any misconception in reference to the hand-bill, I may mention that it is not the instrument purchased from ironmongers under that name, with a sharp edge on

back and front, which is, in comparison, but a feeble instrument. The difference and advantage of the one over the other can only be found out in using it.

Pruning was performed at the same time as the thinning, and cost 5s. per acre, or 1s. per 100 trees. The principal requirements in pruning here were to relieve double stems and double tops, to clear the trunks of lateral branches to one-third of their height, to remove decayed branches, and to cut over injured or decayed trees.

Owing to the sickly and generally unhealthy state of the larch, it was thinned out with a free hand to the number of about 550 trees per acre, including decayed ones. Out of this number only 2500 trees in all were of a sufficient size for net-stakes, the others being inferior, and fit only for pea-stakes or training-rods, for which there was no demand in the district.

The Scots pines were thinned out to the number of 400 per acre, none of which were of any use; for though some of them were large enough for net-stakes, they were too soft for that purpose.

Spruces were thinned out to the number of 400 per acre: 10 out of every 100 were fit for and made into net-stakes, but were much inferior to the larch, and sold at one-fourth less money.

Including hardwoods and all sorts, 1500 trees in all per acre were thinned out, leaving the crop upon the ground at 5 to 6 feet apart, being at least twice the number that should have stood upon the ground at the time, if they had been properly clothed with branches. Owing to the latter defect they were thinned sparingly.

The work of thinning cost at the rate of 40s. per acre, or 2s. 8d. per 100 trees. This included pruning, collecting, and carrying out useful thinnings only (not

the branches or useless weeds), which latter, if cleared out, would have cost a sum at least equal to that of thinning. The money received for net-stakes was £8, 10s., which, after deducting 1s. 8d. per 100 for making, left to the proprietor 14s. 7½d. per acre as clear return from the ten acres thinned; 8s. 4d. per 100 received for the stakes.

It may here be stated that during the performance of the work of thinning the workmen had a distance of from four to five miles to walk night and morning, which made a difference in the amount of labour of fully one-fifth over that of doing the work near their homes.

The causes of failure are numerous; but the chief one is that of mixing trees together that should always be grown separately, they being uncongenial and antagonistic in their natural habits of growth. The soil being naturally damp, a free current of air and the direct rays of the sun are essential to evaporate the noxious vapours and impart life to the languishing trees. Unfortunately the very reverse of this was the case, the crowded condition of the trees precluding both sun and air.

Thinning in this case should have been performed at five years on the west side of the plantation, and at six years on the opposite side. Part of the latter is composed of a large proportion of Scots pines, standing upon the ground to the number of about 1500 trees per acre. Some of the trees, indeed, though fourteen years planted, were standing not more than 4 feet apart, 12 to 16 feet in height, with stems not over 8 to 10 inches girth at the ground, thus exhibiting an unfavourable example in thinning, to be carefully and timeously avoided. Trees of the above age so situated

should not, if properly thinned, be standing closer than 7 to 8 feet apart. The cost in thinning at six years planted is about 5s. per acre, whereas now it will cost twelve times that sum.

In thinning at five or six years planted, the thinnings are, of course, of little or no value, consequently the labour bestowed is a dead loss of 5s. per acre. In thinning at eight or ten years planted, the thinnings, as in this instance, are worth 14s. 7½d. per acre, but then the cost of labour was 40s. per acre; thus showing that, in point of economy, the former period is to be preferred, while the advantages resulting to the future crop cannot be over-estimated.

The results arising from deficiency of branches on Scots pine is seen at a comparatively early stage of their growth, while the full amount of injury which hardwoods sustain from a similar cause are not fully shown till the trees are from forty to fifty years planted, at which time it is often unhappily discovered that the trees, instead of being worth shillings or pounds, are found to be worth only pence or shillings.

CHAPTER X.

THINNING YOUNG HARDWOOD PLANTATIONS.

THINNING young hardwood plantations is a department of forestry essentially different from that of thinning pine and fir. Not only is it different in the general procedure, but also in regard to each species of tree, as the oak, ash, elm, &c., require an entirely different treatment the one from the other; and this leads us back to the planting operation, for, as has been repeatedly stated (under Planting), anything done wrong in planting is a wrong done for ever.

Seeing, then, that each species of tree requires a special mode of treatment peculiar to itself, the question at once arises, How can proper justice be done to each individual tree, when the one next it requires treatment so widely different? Take the oak and ash, for example: the former is growing bent or crooked, for shipbuilding, and is best so grown for that purpose; but the latter is grown straight, so that each grain and tissue may run continuously straight without cutting through it in the workmanship.

A crooked tree and a straight one cannot well grow together, for the simple and obvious reason that they do not agree. Grouping, therefore, is the system that decidedly commends itself, not only to the planter,

thinner, and pruner, but also to the proprietor, wood-merchant, and mechanic.

It will be found by any one who carefully studies the subject, that the most valuable crop of timber is always that of one species of tree only, and not a mixture. Oak, ash, elm, sycamore, Scots fir, larch, spruce, or silver fir, any of which, constituting a group, will be found of much more value than any of them are when mixed with others.

The following examples will show how thinning ought to be done in order to grow the most valuable crop of timber at the least expense:—

No. 1 is a small oak plantation of about 2 acres, grown on the Buckhurst Park estate in Sussex. The site of the plantation was originally an orchard of fruit-trees, and when discontinued as such, was planted with oak-trees exclusively. It was originally planted very close, probably less than 3 feet apart, and nothing was done to it till fourteen to sixteen years old, when a regular thinning was done by cutting out all the inferior growths and such as were suitable for hop-poles; before thinning for this purpose, however, all the trees intended to remain were marked with a ring of paint, to indicate that they were to stand for timber-trees, and denominated *telleurs.* At the time I first saw the plantation (in 1854) the trees stood about 10 feet apart, equal to about 400 to the acre. Each season about ten trees per acre were thinned out, more for the sake of their bark than the value of the wood. The trees were about 30 feet high, and about 15 to 18 inches girth above the swell of the root. What appeared most remarkable about the plantation was the great height of the trees compared with their thickness, and the comparatively slow growth in thick-

ness they were making considering the suitable quality of the soil and other favouring circumstances for their more rapid growth.

The error, mistake, or mismanagement of the plantation was, in the first place, that of either planting too close or being too late in thinning; by the time the hop-poles were cut out from amongst the *telleurs*, the latter were too much drawn up, had lost all their side branches to too great a height, and attained too great height of stem in proportion to their girth.

Another evil, also, was that of continuing thinning after it could no longer benefit the trees. In all such cases of overgrowth before thinning, and when the side branches are killed, there is no longer any possibility of ever making the trees become what they otherwise would have been in regard to size; therefore the next best thing to do is to grow as many trees upon the ground as can be properly done. If the trees cannot be grown large—which they never can be if bereft of their branches—the next object to aim at is to grow more of them. The number on the ground at thirty years old was about 400 to the acre; and of the size and description they were, not a tree should have been further thinned out till the plantation was cut at 150 years or so. The thinning in process was to reduce the number to about 100 trees per acre, and that was a very good aim under other circumstances; but when the trees were not of that description to be ever worth £3 each, the aim should have been to make up the deficiency by numbers—that is to say, by growing three small trees at 20s. where the one at £3 should have grown.

There is a hardwood plantation of considerable interest, from the results of thinning, on Faldonside

estate, in Selkirkshire, grown on the highest ridge of a hill about 500 feet altitude. The plantation was partly mixed and partly in groups, and was rather severely thinned at the time of making that branch of the North British Railway between Hawick and Edinburgh,—part of the sleepers of which were cut out of this plantation. The thinning produced such an unfavourable influence upon the remaining crop, that on cross-cutting any of the remaining trees, the year in which the thinning took place can be still accurately counted. It was not the first season's growth, but the second, third, and so on, that was most unfavourably influenced by the thinning. The first year's growth immediately succeeding the thinning was thicker than those succeeding it, and up to twenty years it had not recovered the shock it sustained; and by the time it would do so, according to the current events of nature, the tree would in all likelihood have succumbed to disease or premature decay.

In Sussex, Kent, and other hop-pole-growing districts, a common practice is to ring with paint a number of select trees at each periodic cutting of the underwood, to grow up as standard timber trees. The intervals between the cuttings of the underwood vary from ten to sixteen years, and when the trees that have been thus grown are cut down, at whatever age, the date of the cutting of the underwood can be easily ascertained by counting the rings or layers; and it is almost invariably found that the increased thickness of the layer varies according to the growth of the underwood, being always least about the second year after cutting, and by degrees regains thickness till another cutting of underwood takes place, and so on throughout. This variation of growth in the rings is quite distinct to

about thirty years old, after which it is more variable and less distinct.

Thinning, then, as may well be concluded, is a very important operation, and one that ought only to be conducted by men of experience and sound judgment, and no others. The benefits of grouping, too, over that of general mixing, is a branch of forestry by far too little studied; and while one would think every one must see and behold the objects immediately before them, yet as a matter of practice many men go on in regard to thinning as if it were either of no importance whether well or ill done, or of no difference which. It might be of no small interest and instruction to those who have leisure to test the state of the atmosphere of a plantation before and after being thinned at the different seasons of summer, winter, spring, and autumn, with one barometer at the surface of the ground, and another several feet above it, and also to test the temperature of the different kinds of trees at their different stages of growth, from the sapling to the mature old tree.

CHAPTER XI.

RULES FOR THINNING.

1. Thinning should be done to preserve the lower branches from withering, and encourage rooting of the tree.

2. Thinning is done to remove small, weakly, and inferior trees, that those of superior growth may have full advantage of space for their development.

3. Thinning is done to regulate the distances of the trees from one another, and to preserve certain kinds by removing other kinds from them.

4. The object of thinning is to prevent rather than cure, and therefore should be done while the trees are comparatively young and small of growth.

5. Thinning ornamental plantations is done differently, because for a different purpose than profitable ones. For ornament, the branches are preserved vital throughout their growth, even to mature old age; while for profit they are to decay and fall off while the tree is yet comparatively young.

6. Thinning advanced pine and fir plantations is very injurious to them, because it allows currents of air and rays of light to penetrate, heat, and dry the soil, while the roots underneath are not prepared for

the change, having been kept cool and in the shade previously.

7. Thinning, when done late, exposes that side of the roots of a tree confronting the one cut down to an undue strain from the prevailing wind, to the rupture of the roots, and even blowing down of the trees.

8. Mixed plantations are more difficult to thin and manage at every stage of growth than plain ones, because the treatment that suits one species of tree does not suit another. Pine and fir should be thinned in early spring, while hardwoods should be thinned when in full leaf.

9. Thinning shelter plantations, belts, and groups, should be done with the object of thickening them. Thinning the stems is thickening the branches, and the more trees are thinned, so long as the branches are healthy and sound, the thicker the plantation becomes, although fewer trees are in it.

10. The larch of all other species is most benefited by thinning, and will reproduce lateral branches when far advanced in age. The oak, on the other hand, though a hardy tree, stands thinning very badly when advanced in age.

SECTION III.

PRUNING

CHAPTER I.

INTRODUCTION.

Opinions, alike numerous and conflicting, are entertained regarding the science, art, and practice of pruning forest-trees; and therefore, before entering upon the various branches of the subject, it may be well to hear what these have to say.

Science has already done much to dispel darkness and diffuse light upon other subjects, and it is not expecting too much of her that she should have done something also for pruning. Science, as far as it appears, is perfectly sound and clear on the subject, but is either too timid or embarrassed to speak out on the subject in language clear and intelligible.

Art is unmistakably in favour of pruning, for she says the culture of forest-trees is mainly for purposes of industry and art, and therefore she is simply doing the initiatory part of her work when she lends her aid to pruning.

Practice is loud in her praises of pruning; but her confusion of voices and chaotic sounds so far obscure her accents as to render her meaning unintelligible, except indeed to the few.

Professor Lindley says, "The object of the pruner is to diminish the number of leaves and branches,

whence it may at once be understood how delicate are the operations he has to practise, and how thorough a knowledge he ought to possess of all the laws which regulate the action of the organs of vegetation. If well directed, pruning is one of the most useful, and if ill directed, it is one of the most mischievous, operations that can take place in forests.

"Pruning may be regarded as a necessary evil, to which the wise must submit because of the ignorant, the careful to cure the evils inflicted by the careless."

No pruning can be considered practical and efficient that does not interpret and clearly explain itself; and no person is capable of judiciously pruning who cannot give a good and intelligent reason for so doing, by explaining it, if not in scientific terms, at least in a manner agreeable to science.

The skilled surgeon scarcely feels less at ease at the sight of the operator's knife in the hands of the surgical tyro, than the skilful forester does on seeing the pruning-knife in the hands of one ignorant of the laws that regulate the healthy condition of plants. A thorough knowledge of vegetable physiology is as essential to the man who practises pruning, as anatomy is to the surgeon who amputates a leg or arm from the human body; and no person is able properly to prune forest-trees who knows not well the structure and whole economy of plants, and the offices which every bud, leaf, twig, branch, limb, stem, or root performs individually, as well as their relationship to one another, and to the whole structure of the tree. I know some foresters who prune well, and yet know almost nothing of science, and also scientific men in whose hands the pruning-knife would be a dangerous weapon. The reason for this is very obvious: the

one man has learned the art and practice of pruning, but never studied science, while the other has learned the science, but neglected the art and practice. When, therefore, a choice must be made between a practical unscientific man and a scientific unpractised one, I would unhesitatingly prefer the former.

The question is frequently asked, Do you approve or disapprove of pruning? The question thus put is unfair, and would therefore elicit an unfair answer. Principles for pruning may be laid down, but rules cannot be given without incurring the risk of doing more harm than good. That certain operations of pruning can be done with good effect there ought to be no doubt or hesitation; but that much mischievous and injurious pruning is done daily is equally certain, and to be lamented. It gladdens the eye and rejoices the heart of every good forester to see right and proper pruning done, and it correspondingly distresses him to see what he is doomed to witness daily in the malpractice of the art. Cutting off a branch is a very simple and unimportant act in itself, but it may be a grand and successful stroke, or a deadly and disastrous one.

The leading principle to be observed is never to cut off a branch from a tree unless absolutely necessary,—necessary in a sense akin to that of amputating of a limb from the human body.

Like many others, we pruned much at an early period of our practice, and having had over a quarter of a century's experience of it, we are now induced to prune comparatively little.

To the question as to whether coniferæ should be pruned we answer, Yes, if they require it, and it is well done. Certain species, particularly those of the fir, larch, and pine tribes, when grown in masses to-

gether in the way they grow in nature, require little or no pruning beyond what nature does for herself in the circumstances. The natural habit of such trees is to produce a balance between stem and branch which is (apart from accident) perfect. It is rare, except when by accident the leading shoot of the stem becomes broken, that the balance of symmetry is disturbed. In such a case pruning is necessary to rectify the disorder, and unless it is attended to in time, the value of the timber will be affected adversely in the majority of cases, and probably the lives of the trees shortened or endangered.

Any such risk is, however, entirely avoided by pruning when the growth is fresh and young; and should any departure from the natural balance of individual trees have been allowed to continue for years, we should say that, instead of operating on limbs which have acquired considerable size, it would be better to let them entirely alone.

CHAPTER II.

WHY PRUNE?

A TREE stands before me as it came from the hand of nature, and I ask myself, What is to be done to the tree? If it is to grow up simply and exclusively as a natural object, without other consideration, I would unhesitatingly say, Do nothing to it at all; let it alone,—for if I touch it in any way so as to produce an effect, I so far violate that law of nature under which it now grows, and was designed in time coming to continue growing.

But if we are fully aware of what this specific principle involves, we must also be prepared for all the consequences naturally arising from such obedience of natural laws. The same law that produces the leaf-moving zephyr, produces also the hurricane; and that which gives us the soft sweet rays of light and heat, gives us also the rolling thunder and flashing lightning.

But before determining that a tree for purely natural purposes is not to be pruned at all *for any reason,* let it be first thoroughly understood what is involved and comprehended in the term *natural,* and when that is done it will be found that to the term *natural* we require to add another term—namely, *appropriate.* A tree with a fractured limb, or broken branch, or split stem, may

be a fit and proper object in a lonely glen or rugged ravine, where a hazardous adventure once or twice in a lifetime may be indulged in to witness the scene, yet the same object in the lawn, or near the mansion, seen by the same eyes day by day, would be universally denounced as an outrage and insult to all refined taste and feeling.

It must therefore be seen that the line here must not, after all, be too rigidly and exclusively drawn; for although the tree is grown purely and simply as a natural object, yet extenuating circumstances may arise whereby pruning is rendered necessary, or at least desirable, and should therefore unhesitatingly be put into practice, as illustrated in the following cases:—

1. When a tree, large or small, has been transplanted from the nursery to the forest, from rich to poor soil, from wet soil to dry, from clay to sand, from loam to moss, from a sheltered to an exposed situation.

2. To lighten the top of a large tree that has been newly transplanted, which is either done by cutting off the top of the tree at a certain distance down, or by lightening some of the larger and heavier limbs and branches.

3. When the tree at any period prior to its destined height of stem branches off into a spreading top without a leader.

4. When a tree from various causes, but principally from the loss of its original top, divides into two parts, each contending for the mastery.

5. When the branches grow off from the main stem at an acute angle, causing the bark between the two surfaces to gall at their junction; all such branches should be timeously pruned off to prevent the limbs

splitting off in future when the tree attains age and size.

6. When branches, from whatever cause, become dead upon the stem or trunk of the tree, and unless pruned off, they remain till a rotten hole is formed in the trunk, which ultimately proves very injurious to the timber.

7. When from certain causes one or more branches grow faster than others, and therefore the stem or trunk above where this occurs suddenly falls off in thickness, to the detriment of the trunk, and in order to induce the part of the stem thus injuriously affected to recover its proper dimensions.

8. Because clean cylindrical stems, with smooth surfaces, are often desired, therefore the trunk of the tree should at all times be kept entirely clear of branches and lateral shoots of every description.

9. Because all trees on the margin of plantations, and on roadsides, extend their branches in the direction they have most room, sunshine, and nourishment; therefore such branches require constantly to be kept within due limits.

10. Because trees do not always grow upright, but, on the contrary, from various causes—as lodgment of snow, winds, &c.—they incline to one side, and thereby occupy more ground than if growing perpendicular.

11. Because, from lodgment of snows, wind, or other causes, certain branches are broken or so bent down as to rub upon others beneath them, thereby galling the bark, sometimes even to the extent of wearing the limb quite through.

12. Because pine and fir trees, as well as others, often lose their top leaders—a circumstance very common in the silver fir and larch.

13. Because, as a natural result of the legitimate growth and culture of pine and fir plantations, the lower tiers of branches die, and when once dead, they should be neatly pruned off.

As respects diseased trees, and even mismanaged woods, prevention is everything—cure next to nothing.

As wide and different opinions, however, prevail, both among theorists and practical men, as to how much and what part art should be called upon to perform in the culture of forest-trees, or how far nature should be allowed to take her own course uncontrolled, it becomes the more necessary to point out carefully the various results of the different modes of pruning, and leave those specially interested to judge for themselves which course to adopt or which to avoid.

When the proportionally large area of pine and fir plantations, and the enormous quantity of trees are considered, the loss or gain occasioned by proper or improper pruning, whether on natural or artificial subjects, must be very great indeed. I shall endeavour to show that the average annual layer of wood should be nearly one-eighth of an inch thick. In order to secure this growth the tree must be furnished with such an abundance of branches as to produce a trunk as many inches in girth, a little above the surface of the ground, as it is feet in height; that is to say, up to that period when thinning ought to be discontinued, say at twenty to thirty years of age. Thinning and pruning are intended to accomplish one and the same result—namely, a fair and proportional growth in the stem or trunk of the tree, and timber of the best and most valuable description. Pruning, however, is sometimes done to accomplish one object, sometimes another, and in other cases several objects combined.

As pine and fir plantations are usually depastured by sheep or cattle, after the trees are sufficiently advanced by the vital branches being beyond their reach—and nothing contributes more to the comfort of the animals, especially sheep, as that of clearing off all ragged, decayed branches to at least 8 feet from the ground, at 8d. to 9d. per 100 trees—not only is the value of the plantation as grazing-ground enhanced by removing all decayed branches that would otherwise catch the wool of the sheep and injure the skins of the cattle, but a free current of air is thereby allowed to waft through the expanse, alike healthful and invigorating to both trees, flocks, and pasture. The air admitted by removal of the dead branches sometimes contributes to the welfare of the trees, and sometimes to their injury—all depending upon the exposure, extent of plantation, and the nature of the soil in which they grow. If soft and clayey, the advantage to the trees is considerable; but if dry and gravelly, injury rather than benefit is incurred.

Coniferæ that are grown thickly together in their natural conditions should receive attention in their earlier years, to prevent any tendency to decline from the balance between branch and stem, which a few years' neglect makes restoration impossible.

The removal of dead branches from all trees is so manifestly desirable from all points of view, that one would think little should require to be said in its favour. Yet there are those who object to do so, on the ground that it is totally unnecessary; that the finest timber, both at home and imported from the natural forests of Northern Europe and America, had never been pruned in any way. They forget, however, that the circumstances that exist in our artificial

plantations are totally different from those of the dense primeval forests whence our important supplies of timber come. "The great density of growth and the larger degree of humidity that obtains in the natural forest, leading to more rapid decomposition of dead organisms, and the constant play and movement of animal life, all tend to clear away the dead branches before they are absorbed to any injurious extent in the increasing growth of the stem." In any case the advantage of removing the dead branches from the stems of trees in our plantations is so self-evident, that it is idle to dwell on the subject at length.

When a limb has lost its functions it can be of no further use to the tree, therefore it should be removed.

The health of the tree is certain to be impaired, and the quality of the timber depreciated, by leaving dead branches to become absorbed by every increasing ring of wood added to the girth of the stem.

CHAPTER III.

HOW TO PRUNE.

PRUNING trees which are simply grown as objects of natural interest, or for the purpose of showing what they would become if left alone to nature would, it is needless to say, under such circumstances, not only be superfluous, but would be lending its influence to frustrate the object in view with all such products. Much, however, depends upon the scope of the object in dealing with such trees; for if planted where they are such prominent and conspicuous objects as to meet the eye at every turn, uudoubtedly, whatever the demands of nature may be, taste will assert its claim; and when a dead branch, broken limb, or distorted leader occurs, from whatever cause, pruning must be done to satisfy taste at almost any cost. The mechanical operations of pruning under such circumstances must be guided entirely by taste, for which there is no fixed law or rule, but in the absence of which it should be observed that the true display of art is always the strictest concealment of it.

In cases where the trees are slender of stem, from 2 to 4 feet high or thereby, they require to be cut over close to the ground with a forester's sharp prun-

ing-knife, and the part cut off sharped and stuck firmly into the ground, close beside the stool from which it was cut. This marks the place where the young shoots are when looked over about midsummer, in order to clear them of grass and other herbage that would otherwise choke them. Next season, when they are again looked over about the same time of the year, the shoots are examined, and the strongest one selected for the future tree. In making the cut, in this as in all other cases, it should be made considerably slanting, or, speaking mathematically, at an angle of about 45°.

In reducing the top weight of trees newly transplanted from one place to another, the practice is to consider, first, how much and what part to cut off. As is well known, when a large tree is lifted its roots are always less or more injured or diminished; and one of the objects in pruning is to lessen the demand for sap in the upper part of the tree, that it may be expended on the lower part. The benefits thus derived, however, though considerable, are not so great as those resulting from reducing the top weight of the tree in order to lessen the strain upon the roots. It is not always the main stem that requires reducing, but sometimes the larger branches as well. It should always be observed, however, that the tree to be thus operated upon should be in vigorous growth and well developed in all its parts.

Many trees, from various circumstances, lose their top-shoot—sometimes from the loss of the terminal bud, and sometimes from damage to the young and tender shoot itself by gales or even birds perching upon it. It is of small moment whatever the producing cause is; but the question remains how best

to impart to it another. If the tree is healthy and of vigorous growth, it is easily accomplished by simply lopping off the top immediately below where it spreads, and allow a new top to form from a young shoot. Where the tree, however, is of slow and stinted growth, and not sufficiently vigorous to produce a new top as directed, the best thing to do is to train one of the strongest and most promising branches as a substitute, which is done by slightly notching the branch to induce it to bend, and by means of two small rods tied to it, to give it an upright direction till it attains strength to keep so. When this expedient is resorted to, the ligatures must be loosened every year to prevent galling of the bark, which would otherwise prove fatal to the tree.

Contending shoots sometimes start at the surface of the ground, and sometimes at points higher up on the stem. Whenever such occur, the contending shoots must be all cut away except the most choice and select one, and preference given to that which springs from nearest the ground.

This is one of the most common and urgent cases for pruning, and one which confers immense benefits on the subjects operated upon. The neglect of this form of pruning is often the loss of what would otherwise have been a valuable tree; and it is no rare or uncommon thing to see a tree in the forest worth only a few shillings, which, if it had been pruned as here directed, would have been worth as many pounds.

Trees are liable at all stages of growth to form what are popularly termed double tops; and when this occurs within reach of the hand, one of the contending shoots can be readily cut off, either by means

of the pruning-knife, or, if higher up, the pruning chisel and mallet must be used. In making the cut, whatever the instrument is, the wound should be neatly smoothed over and painted with any colour of paint as near the colour of the bark of the tree as possible. Attention to contending top leaders, so as to direct the top-growth of the tree not only in hardwoods but conifers as well, is a branch of pruning of the very highest importance, and should always be kept well in hand. In making choice of the leader, its position on the tree, as influenced by the prevailing winds, should be well considered, and also the proportional growth of girth and height, so that if the stem is small in girth compared with its height, instead of cutting off the contending shoot quite close to the stem, only half its length may be cut at first, and the other part close to the stem at a future period.

Certain branches are so grown that an acute angle is formed between the branch and the stem, and as they develop, the bark of the two surfaces is so compressed between them that they form an unsafe and insecure junction—so much so, indeed, that when the tree advances in size, and the branches become limbs, they split off by wind or snows, and even by their own natural weight of foliage in a wet or dewy day. Such branches should either be reduced in size, cut off close to the stem at once, or by degrees, as the health and development of the tree suggest.

Dead and decaying branches are to be found upon all properly grown forest-trees at one stage or other of their growth, from the simple circumstance that, as the upper branches grow and spread, they shade the lower ones from light and air till they die. Now the

question is, how to treat such decayed branches when they occur. If left upon the tree, they become embedded into the solid wood of the stem, and thereby leave a blemish less or more serious, according to the size of the branch and number of years it remains

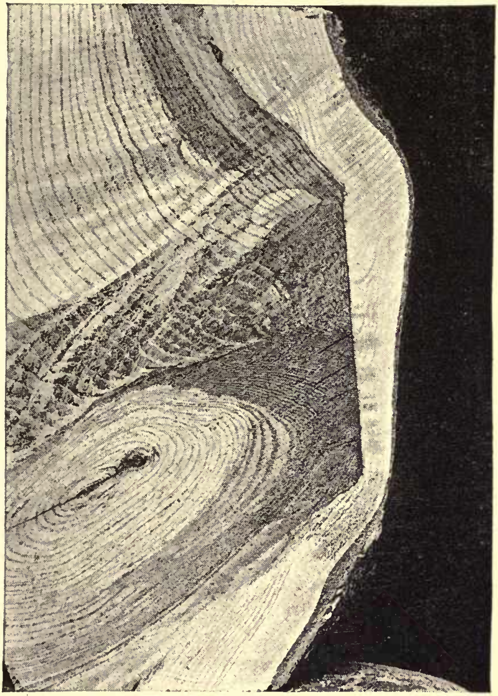

Fig. 6.

before it falls off from decay; and if pruned off, there is a blemish made, which undoubtedly, to some extent, injures the quality of the timber. See fig. 6, branch cut and healed after pruning; fig. 7, dead branch causing black knots, which should be pruned off at line A A.

Therefore, of the two evils, we should choose the least—and that is, to cut off the decayed branch as close to the stem of the tree as possible, and apply paint, creosote, pitch, tar, or other preservative to protect the wound from decay till it heal over by the bark covering it.

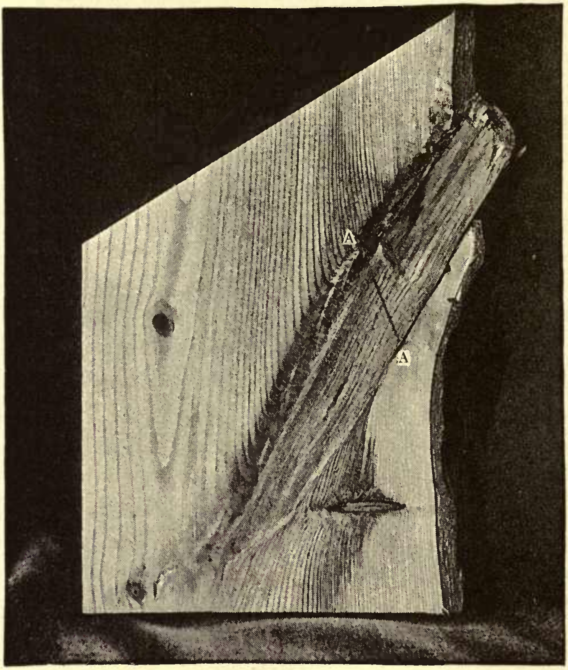

Fig. 7.

Pruning off decayed branches, let it be observed, should be confined to comparatively young and fast growing trees, and should not apply to mature or aged ones. Above all, let no one think of pruning the horny arms from an old ornamental oak or Span-

ish chestnut, or indeed any very old trees; for while it would in nowise benefit the tree by imparting to it life or health, it would certainly very much detract from its romantic and picturesque beauty. We might just as well pluck the grey hairs from the locks of the octogenarian, as prune the whitened withered limbs from old trees. The latter recommendations, be it observed, only apply to hardwood trees, and not to pines generally, which are elsewhere treated of.

Where a large branch or limb takes place, the trunk or stem of the tree immediately above where it occurs diminishes in size to an extent about equal to what the branch or limb increases. And in order to prevent this evil (for it cannot be cured), the limb, or part of it at least, is cut at such distance from the stem as circumstances may direct. Sometimes one-half the entire length of the branch is cut off, sometimes two-thirds, and in other cases less or more, as the age, size of the tree, state of its health, amount of branches, &c., would suggest.

Let it be further explained that, by cutting off a branch or limb, the sap which formerly flowed into it does not now, after the branch is cut off, flow into the trunk either above or below where the branch was situated. What is therefore done for the benefit of the tree, by amputating the limb, is to stop the excessive growth in that particular part, and by *indirectly* inducing the stem above where the limb formerly grew to produce a class of new branches of its own.

A clean stem or trunk is a quality in a tree much to be admired, and worthy of being obtained; and in many cases the only way of doing so is by the aid of pruning. Not, certainly, in the way and manner it

often is, for it is often produced at by far too great a cost. Indeed the most proper way of securing a clean stem is accomplished by thinning rather than by pruning; and even with the aid of both thinning and pruning, it will not always succeed without a sheltered situation. Handsome trees and clean stems are only attainable to the full extent where soil and situation combine to favour them. Pruning, however, has often an important part to perform in the work, which is principally done by checking the lateral growth of the branches so as to induce them to decay, and when decayed, to prune them off close to the stem, dress and paint the wounds, and leave them to nature to restore.

It should never be attempted by pruning to make all trees in a plantation grow with a clean and straight stem, for that is neither practical nor desirable. Trees of every kind and description are required in the works of industry and art; and while for one purpose a straight clean trunk is required, for another a bent or crooked one is sought after.

Therefore in true forestry every tree should be guided in that direction which nature designed it to grow in, rather than strive to subvert nature from her own course.

Trees grown on the margins of plantations, in hedgerows, by the sides of roads and carriage-drives, &c., almost invariably require their branches so pruned as to keep them within due limits. This form of pruning, as may well be understood, is not done with the view to benefit the trees themselves, but simply to confine them within a given area. The two most important considerations connected with this department of pruning are—cutting the branches so that the cut

is not observable, and that the trunk itself is not injured by the operation.

In doing this work two men are generally required —one on the tree to perform the mechanical part of the work, and the other on the ground directing him how and where to cut the branch. Details of this branch of pruning it is futile to attempt giving, because so much depends on the taste and skill of the operator as well as the kind of subject to be treated. As well attempt to teach drawing or music by theory, as this branch of pruning by anything else than skill and practice.

For the guidance of those, however, who may never have pruned a tree or seen it done, the following directions may be found useful.

No one should attempt pruning advanced trees unless he has a good nerve, steady head, and energy, combined with patience and good taste. No attempt should be made to remove a large branch at one cut, so that it may not require a second, or even a third; for, as is but too well known in practice, branches almost invariably split before they are cut quite through, and therefore so far damage the part below as to render a second cutting absolutely necessary. Of course the size and weight of the branch influence the operation materially in every case, and must therefore be carefully studied. To modify the tendency of the branch to split downwards toward the stem, the back of the saw should be held so as to incline downwards towards the trunk of the tree, by which means the split will incline the other way, and thus prevent very materially the danger of damaging the stem by the limb splitting off.

Pruning in such cases is essential, otherwise the

tree for all ordinary, or it might be said for almost any purpose, is rendered useless. In operating upon such subjects, it is well to consider at what particular point to cut the stem; for the object in pruning, be it observed, is to form a new top to constitute the future tree.

Broken and damaged branches requiring pruning necessarily vary according to the different nature of the case. In some cases the branch is cut off quite close to the stem or trunk, and in others at various distances from it; but as far as possible the cut should be done at a little above where another smaller branch takes its rise. When this can be done, it renders the mark less observable than it would otherwise be. When it is impracticable to cut the injured branch at least 3 or 4 feet from the trunk, it is better, for appearance' sake, to cut it quite close; but in doing so two things should be kept in view—namely, cutting so as neither to leave a stump, like an artificial peg, projecting from the stem, nor by incurring a hole in the trunk by decay of the wounded part. To secure the latter object dress smoothly, and paint so as to prevent water entering the wound.

Pruning with the Chisel and Mallet.—For conducting this department of pruning, the long and short handled chisels should usually be employed. The short chisel is convenient of about 10 to 12 feet long, and the long one 18 to 20 feet. The handles require to be of the very best redwood pine, so as to be at once both strong and light. It of course requires two persons to do the work—the one to hold and guide the chisel, and the other to strike with the mallet. Double tops thus pruned, especially on pines or firs, require no dressing, as they are so high up on the tree

as to be mostly unobservable, unless in a valley where they are looked down upon. Where good forestry is carried out, this department is always attended to, and is one of the most useful branches of pruning. All such contending shoots are cut off close to the stem, unless in cases where the operation had been so long neglected as to leave a bare side of the tree. In the latter case, instead of cutting quite close to the stem, the contending branch may be cut at any convenient distance from it, for the purpose of maintaining the symmetry of the tree.

PRUNING PINE AND FIR PLANTATIONS.

Much has been said on this branch of the subject, and ably discussed amongst practical foresters.

In the growth and culture of pine and fir plantations, the natural result is, that as the upper tiers of branches grow, the lower ones wither and decay. This is caused by the side branches being confined and limited in space. It is a common thing for pine and fir plantations at thirty years old to stand about 8 feet apart, which gives each branch a spread of only about 4 feet; and as the upper tiers attain their full extent of growth, the lower ones naturally die. When undisturbed by thinning, and the area of plantation is of considerable extent, the branches rot and drop off of their own accord; but if by undue admission of light and air, as produced by thinning, the branches are thereby induced to harden, they remain for years upon the tree before falling off, and thus impart to the future timber knots of a very injurious and hurtful kind—what the wood-merchants call black knots (see fig. 7, p. 224), which detract very seriously from its

value in the market. If trees could be grown without such branches and corresponding knots, it would be a very good and desirable thing; but as that is an impossibility, in the nature of things, the next best thing to do is to minimise the evils resulting from them, which can best be done by pruning off the dead branches as they occur on the tree. The lower part of the stem is best cleared by means of the pruning handsaw to a height of above 8 feet; and what occurs above that height must be pruned off with the pruning-chisel, cutting close to the stem, but carefully avoiding injury to the bark. It is not affirmed that this is unattended by any evil results at all, for there are spots and marks thereby produced in the manufactured wood, in spite of all that can be said and done to prevent it (see fig. 6, p. 223). These, however, are so small and unimportant in comparison with what would otherwise be the result if not pruned, that there is no comparison between what is the actual result from pruning and would otherwise be the result if not pruned.

For the sake of those who wish to obtain a full knowledge of the principles and practice of pruning, we subjoin the following instances at some length, even at the risk of some repetition of what was said in last chapter: first, as applicable to hardwood trees; and second, with respect to pines and firs—specifying, however, only as many examples as may be deemed sufficient to illustrate the subject:—

1. The first case, when pruning may be considered necessary, is that of a hardwood tree on its being transplanted from the nursery to the forest, from a richer to a poorer soil, from a sheltered to an exposed situation, or from the tree having had the bark gnawed

off by stock or game, or having become otherwise injured so as to cause it to die down to or near the surface of the ground, or the top having become dead, which latter occurrence frequently takes place in larger ones, particularly if imperfectly rooted previous to transplanting. In this case, the only sure means for recovery of the tree is to cut it over,—in small plants, within an inch or so of the ground's surface, and the part cut off stripped of the small branches, sharped on the thick end, and stuck firmly into the ground close by the side of the stool from which it was cut off. This forms a future mark for the pruner when he goes over the stools in June or July to clear away from them all superfluous shoots, leaving only the strongest and straightest on each to form the future tree.

With regard to trees of more advanced growth whose top has decayed, we cut off only the dead part back to where the stem is vital, allowing a leader to start from the strongest shoot upon the stem. This we often find of advantage where cattle or other animals would be likely to destroy the trees if within their reach.

2. In transplanting large trees for ornamental purposes, we generally cut a portion off the top, or reduce the number of the large branches; this not only lightens the top of the tree, and prevents the wind from having undue influence upon it, but also causes a larger quantity of sap to ascend what remains of the branches and top thus newly produced.

3. The next case is that of a tree at various periods of its growth, from a sapling upwards, that has branched off into two or more stems. This occurs both when the tree is of spontaneous growth and also when it

has been transplanted; but it must be admitted that it occurs more frequently in the latter case than the former. When this occurs with saplings, it may appear a matter of the smallest importance, but it is far otherwise in the case of a tree when it attains considerable size; thus, not only is the foliage deficient on the inner side of the two limbs confronting each other, but the tree, in consequence of the diminution of branches, is correspondingly injured in its roots. The tree in this form occupies an undue extent of ground, and instead of becoming a beautiful and valuable object, with a compact massive trunk, develops into a mere ramification of limbs and branches, radiating from two or more large ones,—a subject, perhaps, more suited to the artist than the mechanic.

Nor is this the only evil that arises from tolerating such a tendency in the growth of a tree to go on unchecked; for it must be borne in mind that it is now a well-established fact that the roots of trees bear an approximate relationship to the branches, the one extending above and the other beneath the surface of the soil, so that in such cases the roots occupy as undue a space underneath the ground as the branches do above it. Another consequence of the above result is, that the half of a tree which is unfavourably exposed to the prevailing hurricane is often blown down, and the remaining half shares a similar fate when the wind changes round to the opposite quarter. As a remedy, therefore, against this evil, timely pruning is the desideratum. In operating upon a sapling, we cut off at once the branch close to the bole of the tree; but if the limb or branches are too large in proportion to the stem to admit of being cut off at once, we shorten it by degrees till sufficiently small in

proportion to the stem to admit of being cut clean off. Not only is the proportionate size of the branch to be taken into account, but the state of the tree's health at the time must be observed and studied, together with the situation in which it is growing.

These constitute some of the principal features to guide us in determining whether the branches are to be reduced by degrees or cut off at once.

4. When a tree divides into a double top, at a height below what constitutes a good trunk or stem, we lighten one of the tops by cutting off about one-third of its entire length—that is, if the annual growths are large, the top much drawn up, and with few lateral branches upon it; but if the annual growths are comparatively short, say from 12 to 15 inches in length, and fully furnished with lateral twigs, we at once cut away close to the leading stem the less favourable-looking shoot of the two, and in general cases the one that would be most likely to be broken off by the prevailing winds in the locality. Pruning in this case is generally performed by means of the pruning-chisel, which is used to great advantage upon trees when beyond a man's reach.

5. It frequently happens that a tree, from some accident or other, loses its leading top at an early age; the consequence is, that a number of branches strike off in a horizontal direction, but none of them take an upright position, and this renders the tree quite a shrub of a somewhat pendulous and spreading appearance. A tree in this state would probably ever remain as a mere arboret or bush if left to itself. In this case, when hares and rabbits are not to be feared, we at once cut over the tree to within an inch or so of the ground. A young tree is thus allowed to form;

and though the tree, when cut over, may be 6 to 8 feet high at the time, yet in two or three years afterwards (if the tree is healthy) a young sapling will have taken its place, which, though not so strong, will be nearly, if not quite, as tall as the original tree, more handsome, more healthy, and better directed in its upward growth. From this the most promising shoot is selected for the future tree, choosing always that which is lowest down upon the stool. If, however, as is frequently the case, hares or rabbits are to be dreaded, we cut the tree over at a point above their reach, and immediately below where a year's growth terminates, and where few branches exist. A very common occurrence in this case is, that a quantity of spray is formed immediately below the cut, particularly if the tree is at all unhealthy or of stinted growth. Trees thus operated upon in winter and spring should always be again gone over in the succeeding June or July, and all superfluous shoots broken off *with the hand,* which is better than the knife in ordinary cases.

This kind of pruning is seldom necessary except in high and exposed situations; but under such circumstances we have often adopted it with the greatest success.

6. Though oak-trees of the best varieties seldom produce branches forming an acute angle with the stem, yet they do so occasionally—even the true *Quercus robur,* whose branches proverbially grow at almost right angles with the trunk, is in some cases thus affected. Since, then, we find nature producing branches of this description upon trees—and trees thus grown are almost useless for ship- and boat-building purposes, at least unless timeously pruned—art must therefore assist nature, by guiding her in the

path most conducive to the convenience and interest of man; and in no instance can she do this more certainly, and with better success, than in cases such as these. While the young sapling is within reach of the hand, we use only the common pruning-knife, but when above reach, the pruning-chisel must be used; and in doing so we proceed in one of two ways,—viz., when the branch to be operated upon is situated upon a tree of rapid top-growth—that is, when the leading shoot is long and slightly drawn up, with comparatively few branches—we reduce the contending shoot by cutting it back to about one-third or one-half of its entire length; on the contrary, when the tree is tolerably strong in proportion to its height, and is fully developed in its lateral branches, we cut off the branch close to the trunk at once. The object of this department of pruning is to obviate the consequences of the bark growing into the body of the tree, and prevent high winds from splitting off the limbs at any future period of their growth.

With the spokeshave we carefully smooth over the surface of the knot where the branch existed, simultaneously clearing away all decayed matter around the part which the bark does not cover. We next paint over the dressed knot in order to prevent decay in the tree, to protect it till the bark covers it, and also to bring the knot near to the natural colour of the bark of the tree. White-lead mixed with oil, a little lampblack and red ochre, serves in most cases for this purpose, and in mixing may be brought to any desired tint. One of the most efficient preservatives against decay in old trees is an application of Archangel tar. For trees of dark-coloured bark we prefer tar to paint, taking care to apply it sparingly so as not to let it

run or drip in hot weather. Creosote or " oil of tar " is also an excellent preservative; while sheet-lead or zinc alone is often most like the lichen upon the bark of old trees, and for any conspicuous or important part, where a large wound has been caused, it may be made, by a few touches of the brush, an excellent imitation of the bark of an old tree.

7. It frequently happens with trees selected from others closely surrounding them, that at some particular part, or it may be all over the stem, a great quantity of spray is produced; and in consequence of this, that part of the trunk immediately below becomes disproportionately thick in comparison with the part above. The sap is thus in a great measure obstructed in its ascent to the uppermost branches, and the top of the tree is thereby deprived of its due measure of support and enlargement. In order, therefore, to guide the sap, as it were, in the proper direction up the tree, these branches must be diminished. In doing this, we cut off a few of the small ones close to the main stem, and reduce the others by about one-third their original length, taking care in all cases of shortening to cut a little above another branch or small twig, in order to preserve the main branch alive, and also to conceal the cut part. In pruning within policy grounds, or in sight of walks or carriage-drives, considerable art is required to conceal from view the wounds inflicted upon the trees.

8. This is a form of pruning applicable principally to young trees, and the object to be attained is their general proportionate development, as a remedy against undue enlargement of the tree below any great mass of branches, by diminishing which the sap is induced

to ascend, so as to nourish and enlarge the attenuated part above.

9. It is frequently indispensable to have timber trees with a clean, straight, and tall trunk, free from knots, and clear of lateral branches to a considerable height; and in order to attain this in the most perfect way, the trees should be grown only at such distances apart as sufficiently to check their side branches. This, however, is sometimes impracticable, and cannot be done; hence pruning is adopted.

Without attempting to explain all about pruning, or even fully exhausting any one of its departments, we shall endeavour to lay down a few of the leading principles that should guide us in the operation of daily work.

When an operation is to be performed upon the human body, the general state of the patient's health is first carefully considered. In like manner, when pruning is to be performed, whether upon a single tree, small group, a shelter-belt, an extensive plantation, or forest, the state and condition of the subject must be thoughtfully considered and deliberated upon somewhat in this manner:—

Is the exposure severe, or is it sheltered? Is the prevailing wind from the north, south, east, or west? When was, or when must, *thinning* be done? Is the soil such as to produce vigorous growth in the trees, or is it the reverse of this? Are the trees to be pruned intended for shipbuilding or boatbuilding? or are they intended for general economical and industrial purposes? or are they only intended for shelter to the estate, ornamental and beautifying purposes?

CHAPTER IV.

BENEFITS OF PRUNING.

Having thus shown why pruning should be done, and how the various branches of it are performed, it may appear quite superfluous to say anything more on the subject. Nor would it be at all necessary, but for the simple reason that the various practices of pruning have been in operation for so many years, that every one has his own theory, system, and programme made out whereby to proceed. It is therefore necessary to show not only what is right and proper, good and commendable, in regard to it, but also what is wrong, hurtful, improper, and dangerous in the practice. We have therefore, in point of fact, to destroy one programme and construct another.

Pruning has gained for itself a history, and that history requires to be reviewed, and the lessons it has taught us put on record for our example or warning, that we may see what of truth and what of error it contains, how much or how little is to be retained or discarded. It is also desirable to show how much of what has been learned should be unlearned, and what has been done should be undone. Experience however teaches us, in regard to things in general, that it is much harder and difficult to unlearn than it is to

learn. So presumably, also, in regard to pruning; and until ocular demonstration is given of the errors of the past and truths of the present, there is but little hope of introducing any better or more improved system, but it will be our best though humble endeavour to try.

When pruning is done upon trees which actually require it, they are benefited by it in various degrees. Some are benefited immensely, and others very little. Some trees are so grown that unless pruned they are utterly worthless, and constitute mere cumberers of the ground, while if pruned in the right way and at the proper time, they are thereby increased in value manifold.

In order to be plain and practical, however, it is also necessary to be pointed, explicit, and go into details.

Take the oak-tree, for example, which is generally regarded as the king of forest-trees, and see how and in what manner that tree can be benefited by pruning. Those who have seen the two historical trees in Jed Forest, near Jedburgh—the Capon-tree and King of the Wood, the latter (fig. 8), which also constitutes our frontispiece, and the former, as here shown in fig. 9—will observe how differently the two trees are grown, and how much more commercial value the one is than the other.

The King of the Wood is as fine a timber tree as the eye can rest upon or the heart desire, with an immense upright trunk, beautifully branched on all sides; the first tiers of branches begin at 10 feet from the ground, well clothed, equally balanced, and finely proportioned all over. It is all but certain this tree was never pruned, and in all likelihood it is grown direct from the acorn. Its early history is, of course, a

matter of conjecture; but it may fairly be computed at 70 feet in height, 14 feet in circumference, and three hundred years old, and containing as many cubic feet of timber, and worth £50—as a timber tree. Now

Fig. 8.—The King of the Wood.

in regard to this tree, it needed no pruning, and anything done to it in that way would have injured rather than improved or increased its value.

The Capon-tree, on the other hand, as will be seen

in the fig., has grown indirectly but not directly from the acorn, and is probably a scion from another tree, and that, again, probably also a scion sprung from a scrubby, gnarled shrublet five hundred years ago. The Capon-tree, though occupying much more ground than the King of the Wood, is yet of little or no commercial value, which timeous pruning might have corrected, and probably made as valuable as its neighbouring monarch.

Fig. 9.—The Capon-tree.

The following are also cases where pruning is commendable, and of very decided advantage.

1. Where two or more contending shoots grow up together, either starting from the neck of the tree or from any point farther up on the stem, as is very common in the silver fir, the larch, and cedars, including the *deodar*,—in all such cases we relieve the tree of all except one to form the stem of the tree.

2. Where, from accident or other cause, a tree loses

its leading top, and strives to regain it, assistance should be given, either by means of the knife, saw, or pruning-chisel, to enable it to do so.

The pruning-chisel is the best instrument for this purpose, as the top, where the operation is to take place, is too slender to carry even a light boy, so that long- and short-handled chisels are the best instruments to use for the work, and by them much good can be accomplished.

3. Where the branches have become dead and withered, which the lower ones of conifers always do, except in the case of single trees standing openly, such branches should always be cut off close to the stem of the tree as soon as vitality has ceased, which is best done by means of a small-toothed sharp hand-saw. If the branches are allowed to remain upon the tree after becoming withered, they get embedded in the wood, and remain attached to it sometimes over seventy years, producing all the while what ultimately forms the lamented black knots, which is one of the greatest detriments to wood, especially when cut into boards or small scantlings.

The cutting off of withered branches, no doubt, produces a partial evil, by leaving a discoloured streak in the wood, but the evil thus inflicted is infinitely smaller than that produced by allowing the dead branches to remain on.

4. There is another species of pruning termed disbudding, which is generally practised upon comparatively young plants, and is at times useful in directing a leading shoot, or retarding the growth of an ambitious one, or side branch. This practice consists in simply pinching out the large central bud at the point of the shoot, and is best performed in autumn or winter.

5. There is yet another practice of pruning, which differs from either cutting the branch or disbudding it, and yet answers the purposes of either, which is simply pinching off with the fingers the points of the young shoots when about two-thirds grown. This, of all others, has the best effect of stopping the growth in any direction without incurring evil consequences. It is chiefly performed upon young plants in the nursery, or single ornamental trees in pleasure-grounds, where any special effect is required, but is quite impracticable as a general forest operation.

Any species of pruning necessary to be done to coniferæ is attended with less risk or injury to the tree than to hardwoods generally as the wound inflicted is immediately covered with resin, which soon hardens and completely stops running or bleeding; and not only is the surface of the wounded part coated over, but the wood to a considerable depth is filled with crystallised resin, to the complete exclusion of air, water, fungi, and rot. Thus nature both compounds and administers her own balm to the wound, thereby dispensing with paint and other artificial appliances. Our own practice in pruning pines or firs, when cutting the branch, is to rub the wound all over with an earthy turf, which not only assists in restoring the cut part to the natural colour of the bark, but also in forming a crustation to the wound by the earth mixing with the resin.

Of the common species of coniferæ, none require or stand pruning so well as the larch and silver fir, as both are apt to produce plurality of leaders, and both submit well to their removal. Indeed, but for the removal of double shoots of the silver fir, it would seldom attain half its value as a timber tree.

Another case for pruning is that of branches having become dead upon a tree. So long as the branches are vital, they are in a state of growth and enlargement, forming woody layers along with, and in conjunction with, the trunk of the tree, whence they issue ; but as soon as life ceases in the branch, the annual layers of wood upon the trunk, by continuing to increase gradually, absorb the base of the dead branch attached to it, and which, when enveloped in the wood of the trunk, forms the said lamented black knot. If this occurs in a young tree, while the branch is a comparative sapling without heart-wood, it soon decays and falls off without any serious consequence; but when a large branch dies upon a tree after the heart-wood is formed in it, an evil of no small magnitude is incurred. The dead branch in this state remains upon the tree for many years, till embedded deeply in the trunk. The consequence is, that when the tree is sawn into boards or thin scantlings, a black knot is frequently found to go right through it, and on the wood being seasoned it frequently falls out, thereby leaving a hole in the wood, and rendering it useless for many purposes. Therefore, in all cases of young growing plantations, we at once prune off all decayed branches from the main body of the tree; it is not necessary to prune branches off branches, or even off small limbs, but only off those parts of a tree which yield timber proper. In pruning off dead wood from young trees, we use only the pruning-knife or chisel; but when the trees are aged, and the heart-wood formed in the branches, the operation is performed by other means.

It is often difficult to say what the truly natural habits of trees are, as soil, climate, and situation have each a powerful influence in altering their appearances,

and even their qualities. We find that when trees are grown singly, and are fully and openly exposed to sun and air, they are, in most instances, clothed with branches from near the surface of the ground to the top, so that the aid of art is called to assist in producing a clean, tall, handsome, and useful tree. Pruning in this case might be almost, if not altogether, rendered unnecessary by timely and judicious thinning; yet, as already shown, this, in the general management of woods, is found impracticable, and consequently pruning is rendered necessary. The operation of clearing the bole of a tree is the simplest of all departments of pruning, and is performed upon young trees with the pruning-knife; but in the case of tall trees and those further advanced, the pruning-chisel is employed.

As a general rule, the trunk of the tree is kept clear of branches to about one-third of its entire height: thus a tree 30 feet in height should have a clean trunk of 10 feet, and a tree 60 feet high, a trunk clear to 20 feet. In low-lying sheltered situations, where the soil is deep, the trunk of the tree may be cleared to nearly half its entire height. Though this is the simplest of all pruning, yet it is in many cases sadly abused by clearing the tree of its branches to near the top, and doing the work roughly and inartistically.

It is often found necessary, although not altogether desirable, to prune trees in hedgerows, and along avenues, rides, carriage-drives, and roadsides, not with the view of benefiting the tree, but only to check the growth of the branches, and prevent them from unduly hanging over, shading surrounding crops, and impeding traffic upon roads. In this case the principal duty

required is to lop off the offending branches without imparting to the tree a mutilated, unnatural appearance, to cut each branch so as to leave the part remaining upon the tree in such a state as sufficiently to elaborate the sap and maintain its vitality. In the operation itself, sometimes the saw and spokeshave, and sometimes the pruning-chisel, is used; but in either case the greatest skill is required in amputating the branch in such a manner as to be altogether unobserved.

In this department of pruning, as in most others, no positive definite rule can be laid down as applicable to all cases, since the entire execution of the work depends upon the taste and skill of the operator. We always cut either close to the trunk of the tree, and dress and paint the knot so as to avoid observation, or cut at such a considerable distance from it as to secure and maintain vitality in the branch, and preserve the symmetry and outline of the tree.

In amputating a large limb, we always endeavour to do so within an inch or so of a smaller branch; and thus many a noble tree is prevented from falling a victim to the woodman's axe, or being subjected to a tortuous mutilation. It is unaccountable how proprietors of cultivated minds and refined taste can tolerate the unskilful and distasteful manner in which handsome and often noble trees are so outrageously disfigured by unscientific and inartistic pruning. But, as already remarked, this instance of pruning is not performed with a view to improve or benefit the tree, but simply for other and yet very important reasons.

In the case of large branches growing upon one side of a tree, such branches, from being disproportionately large, attract an undue amount of nourishment to

themselves; thus a tendency is created to overbalance the tree by an excessive weight of branches and foliage on one side. A tree thus unequally balanced increases in woody matter on that side to which it inclines, and this evil is increased as the tree advances in size. This seemingly unimportant circumstance, which commenced in a disproportionately large branch, soon becomes magnified to such an extent as to terminate in very mischievous results. A reclining tree occupies much more space than an upright one does; it is more subject to be loaded and broken down with snow; it is unequally rooted on opposite sides, consequently more liable to be blown down with winds; and the annual layers of wood being much thicker upon the under than upon the upper side of the tree, the timber manufactured from such trees twists and warps in such a manner as to render it useless for many important purposes—therefore the necessity of pruning in order to properly balance the tree and produce timber of good quality.

It sometimes happens, from the weight of fruit or foliage upon a horizontal branch, from lodgment of snow, or some other cause, that a branch or limb is so bent down as to rest upon another below it, and, from the friction by the wind, the two branches are rubbed upon each other, producing wild irritating sounds and mutually disfiguring each other. During heavy falls of snow we have seen many noble trees thus all but totally destroyed, which, by timely attention to the removal of such branches, might have been entirely prevented.

Pruning as a branch of forestry is not in general uniformly well directed, and as seldom well performed. Upon some estates it is altogether neglected and its

importance ignored, while upon others it is carried on to an injurious and hurtful extent.

Upon some estates the system pursued is a wrong one; and upon others, while the system is right, the execution of the work is so rude and barbarous that any one seeing it is justified in wishing the work had never been done at all. That which leads to wrong-doing generally is wrong thinking, and if a word can be said in such a way as to turn the current of thought, the hand that might perpetrate mischief may be thereby arrested.

One common impression in regard to pruning is, that when an important limb or branch is cut off from the bole of the tree, the sap which was wont to flow into it, to nourish and sustain it, will, on its being cut off, find its way into the stem or bole of the tree, and thereby nourish and enlarge it to the full extent that it did the member cut off. That this is a wrong impression can be easily shown, and also that the anticipated benefits resulting from such pruning are never realised.

If it be asked how it is ascertained that the sap which formerly sustained the amputated limb does not find its way into the trunk, and add nourishment to it proportionately (or to an appreciable extent) to what it did to the limb, the answer is, by experience and observation, such as any one may avail himself of at pleasure. I have several sections of wood before me, taken from trees previously pruned, all of which show that the sap-vessels of the stem or limbs adjacent to that cut off do not enlarge or increase in strength subsequent to the operation. In most of the sections I observe a diminution of growth rather than an increase, such as is produced upon a neighbouring tree

by the act of thinning. The sap does not flow in one class of vessels only, but in several; not in longitudinal ones only, but transverse ones as well. Each branch and limb evidently has a primary class of longitudinal sap-vessels peculiarly its own for conveying its nourishment, but in addition to these there is a secondary class of transverse ones, all connected one with another, and with every part of the tree to its remotest extremities. This is clearly demonstrated by cutting off a branch and leaving the smallest ligature on the outer surface along with the bark, which is found sufficient to keep the whole branch supplied with sap alive for an indefinite length of time; or what is still more remarkable and illustrative of the affinity of sap-vessels and their connection one with another, is the experiment of cutting down a tree of any size, small or great, and leaving the slightest connection of the sap-wood entire at the root. By this means I have seen a beech-tree of large size kept alive for many years, and no part of it suffer decay, not even the extremities of the branches, notwithstanding that the sap-vessels through which the whole structure of the tree was nourished and supplied with sap were not over 4 inches by 1½ inch, including the bark. Trees in this state of prostration, and with the limited supply of sap, do not make any perceptible enlargement either in shoots or woody substance; but the circumstance of their budding, foliating, and defoliating the same as other trees, shows conclusively that the sap becomes common throughout the whole structure of the tree, and though entering by a small channel and only a limited number of vessels, it soon spreads into other channels, and extends uniformly to all parts of the tree.

The foregoing remarks, while admittedly a digression from the real subject of pruning, may be excused on the ground of their relationship to it, or at least on account of their showing the importance of sap-vessels, and how they act and react upon each other, without a knowledge of which no system of pruning can ever be made intelligible and satisfactory. A forester's knowledge of the growth of a tree, and how it is produced, is probably better shown by the manner in which he executes pruning than by anything else.

That the roots supply the tree with nourishment is no more certain than that the tree supplies the roots with the power and means of doing so; for there is no more certain means of arresting root-supply than by denuding a tree of its branches and leaves. The deprivation of its leaves not only prevents the tree from forming and maturing its wood, but will very soon deprive it of vitality altogether. In the year 1865 the caterpillar attacked the natural birch woods in Strathspey, and rendered them in many cases leafless, the result of which was that many trees died. It is the branches situated upon the lower part of the stem, too, that principally nourish the roots, and when these, in the act of pruning, are taken away, the baneful consequences may be readily apprehended. Clearing the stem of all branches, great and small, is done in order to form a beautiful, clean, cylindrical trunk; but however laudable that object is, its attainment must not be secured in that way; indeed, the very means employed are just such as to frustrate the object in view. No one is more enraptured with a splendid trunk than I am, and every forester should aim at such an attainment; but while he is so aiming, it is absolutely necessary that the means adapted to that end be the

right and proper means. The stem, as I have repeatedly stated, should, in the case of a well-grown tree, girth as many inches round as it stands feet in height. When this rule is attended to, all under and over pruning will be prevented; and the same rule is applicable to all species of forest-trees grown for profit as a crop. Tastes and fashions are applied to trees as well as to persons; and it ought to be the aim of all who in any way influence fashion, to do what they can to make her servant to, not mistress over, nature and her laws.

Pruning is a subject of such momentous importance that it cannot well be over-estimated, nor can too much be said about it, or it be too deeply impressed upon the minds of every one concerned. Like any other art, science, or branch of education, when one department is thoroughly mastered, it opens up and clears the way for others. Knowledge, no less than ignorance, is contagious; hence, when one is truly espoused, others join company and follow in the wake.

CHAPTER V.

EVIL EFFECTS OF PRUNING.

In regard to pruning as a specific for unhealthy or diseased trees, by imparting vitality through enriching and liquefying the dry unhealthy bark: this is only another imaginary benefit, void of any practical truth, suggested, in all likelihood, by the vigorous fresh spray or young shoots which burst forth from any suddenly exposed part of the stem, or from interruption or derangement of the sap-vessels. It is quite a common circumstance to see trees at all stages of growth, from the sapling upwards, whether as growing trees or after being cut down, exercise a sort of dying effort, and make a display of splendid, young, healthy foliage and vigorous shoots, which continue growing in autumn a full month after the older and undisturbed branches have matured their wood and ceased to grow: proving, not as some would have it, that the tree has regained vitality and is recovering from a state of lethargy or disease, but, on the contrary, that it is making a last spasmodic effort to prolong life at a great and dangerous sacrifice,—living, as it were, upon itself, and consuming its own vitals in order to make a fair but outward show of flickering life.

There are in all trees what are termed latent buds

lying in readiness to embrace any favoured opportunity of appropriating the materials necessary to form active buds and shoots; and when any neighbouring sap-vessel is ruptured, or the sap diverted from its natural course, it so far affects those latent buds as to arouse them into life and action, and ultimately to form buds, branches, and leaves. So easily are these latent buds influenced, that even a slight variation of temperature will do it. It is upon this known principle that thinning is practised, and according to which all pruning should be regulated.

The fine, healthy, and vigorous spray that thus covers the dismembered parts and newly pruned trees during the first summer after the operation has taken place, is very apt to betray those of limited experience, and lead them into fatal errors. The spray thus produced being well nourished and abundantly supplied with sap, is so far accelerated in growth as to prolong its growth in autumn till suddenly stopped by frost, while the wood is yet tender and immature; and consequently a large portion of it withers and decays, and what of it remains still vital is so much weakened and otherwise injured, that the leaves which next season cover it are weakly, ill-formed, small, spotted, and blemished, and scarcely one of them free from disease.

The injurious effects of this form of pruning are not so obvious in conifers as in hardwoods, and are most conspicuous in the oak, wych-elm, and Spanish chestnut.

Ten years ago the writer pruned a considerable number of Scots pine trees in different ways and to different degrees, from that of removing only the terminal shoots of the lateral branches, to that of denuding them of all except as many small twigs upon each

branch as would keep it vital; and the invariable result was a diminution of the thickness of layer of wood in the stem, in some cases the year immediately succeeding the operation, and in others two or three years subsequently; but in every case, just in proportion to the extent of pruning done, so were the unfavourable results. By way of further experiment, the writer denuded some Scots pines of about 6 to 8 feet in height of all their pins or leaves, leaving only the terminal shoots covered; and the results were that, although making annual top-growths of from 12 to 14 inches the year previous, the next season they made only from 3 to 5 inches. The defoliating process was carried on two years longer (three years in all), during which time the top-growth still continued to decrease; but owing to the writer leaving the scene of experiments, he cannot record further results, though the probability is that they would all soon perish.

The top-growth of a number of trees operated upon was likewise materially influenced by the foreshortening practice of pruning, but not so much so as by pruning off the lateral branches. Those most severely pruned of their lateral branches suffered most in their top leader.

The above experiment was made with a view of showing how the top-growth of a tree is influenced by reducing the side branches, and the results shown were, that the top-growth is not promoted by reducing or confining the side branches, but through shelter, by protecting the top of the tree from storm, tempest, and blighting winds, and by deep and congenial soil, by which the whole structure of the tree is nourished and built up. This is very obvious from what may be seen in the natural forest, where trees may be found

standing singly, and of bushy habit, yet making top-growth equal to others growing in groups tall and slender.

We operated upon some larches, by cutting off two or three years' growth, when the trees were about six years planted. The trees were grown at an altitude of about 600 feet, and the top-shoots were about 18 inches in length. This was done with a view of testing the effects of a stimulated growth upon the trees, when, to within four years from the time of the operation, there was a decidedly visible superiority of growth upon them compared with those that had not been cut; but this superiority of growth only continued a short time, and nothing was ultimately gained by it, but, on the contrary, considerable loss: hence, it should not be practised. It is further recommended, in reference to pruning, that no branch be cut from a tree that is not doing positive harm or injury to it, and that every branch be regarded as a source of nourishment to the tree, and every leaf a medium through which the tree is supplied with the elements which build it up.

Spray or young shoots formed immediately after cutting off branches, though vigorous and healthy at first, will, unless the tree is in a very favoured and vigorous state of growth, wholly or partly die or grow sickly the second or third year, and the once broad healthy leaves, which pruning was the cause of producing, become only a noxious unsightly appendage.

One of the causes of improper pruning being so very common, is on account of the fallacious belief that if one branch or limb is cut off, the sap which formerly flowed into it will, after the amputation is done, simply change its current and flow into the adjoining branch

or stem, and thereby impart to the one what was taken from the other.

In the case of a tree growing up with a forked or double stem, one of them is cut away, for the simple reason that, if allowed to grow in that form, the future tree would be less than half the value it would otherwise be with a single stem or trunk.

This, however, is not generally regarded as the principal object gained by cutting away the twin stem; for the popular belief is that if the twin stems are each annually gaining 2 inches in girth, if one of the two is cut away, the one left will not, as formerly, grow only at the rate of 2 inches annually, but 4 inches. This theory, though bearing the semblance of truth, is decidedly a false one; for it will be found by any one who may choose to examine the structure of the wood, years after the operation has taken place, that the layers or zones in the stem had not *increased* as anticipated, but in all likelihood had rather *decreased.* Some sections of wood in our possession, cut for the purpose of examining their structures, show one general, though not uniform, result. Some of them indicate a considerable falling off in the thickness of the layers, beginning with the first season's growth; in others the decrease is not so visible till the second year; but in all the sections the third year's layer is somewhat thinner than the one produced the season in which the operation was made.

How and by what means, then, is the stem ever to be increased in thickness if it thus decreases as above described? It increases by a new and different process of growth altogether, in the following manner: Soon after the twin stems have been separated, the bark of the remaining one begins to show little risings

on the bark here and there, which in due time produce buds; these again form small twigs, and ultimately branches and limbs. It is from this new set of twigs and branches that the stem-growth begins to increase —from no other source, and from no other cause. Now, if we thoroughly understand this principle of physiology, it will help us greatly in regard to pruning, and keep us out of many errors commonly fallen into. The result of pruning is to *create* rather than *develop*: to form a new series of growths rather than increase and extend the old ones. When any branch is cut off, the result is that an embryo bud in its neighbourhood is formed, which develops into a new and distinct branch, and starts growth, as it were, on a new basis, rather than by contributing to the growth of the branch from which it takes its origin. We saw the other day an example of this in a sycamore shoot of underwood, of about 1½ inch in diameter, from which a branch had been lopped off in the ordinary work of heading back game covert. At the cut part a young shoot had started, and at four years' growth had become considerably thicker than the original stem of ten or twelve years' growth, from which it emanated.

Another but fertile object in pruning is to reduce the size of the top of the tree, and change its form, so as to bring it into harmony and proportion with the size of the stem or trunk. In order to this attainment certain branches have to be cut off, or pruned more or less, as the subject suggests. The result of this operation in the case of a healthy tree is, that instead of diminishing the quantity of branches as intended, and also of reducing the size of the top and improving its form, the very opposite results are produced; for instead of the presence of one branch, which was pruned off, sev-

eral are now produced. If only one or two branches at most are produced, they will grow so rapidly as soon to occupy the whole space the former branch did; but if a still greater number are produced, the further result is that quite a profusion of spray is sent forth, alike abundant and sickly, which neither produces proper wood in a forest-tree, nor fruit in a fruit-bearer.

If, instead of the pruned tree being a strong and healthy one, it is, on the contrary, sickly or delicate, the result of pruning in that case would be that the wound inflicted by the operation would not readily, if at all, heal, and thereby disease would be aggravated and decay accelerated, which frequently extends to the trunk and other parts of the tree, to its serious injury, and often ultimate destruction.

That pruning where actually required does much good there can be no manner of doubt, but that the reasons generally assigned for pruning, and the manner and method of doing so are false and delusive, is but too evident. The removal of large limbs from trees of advanced age is sometimes an absolute necessity, such as those overhanging roads, in arable fields, hedges, &c. This, however, is done without any thought or intention of benefiting the tree, but also too often without the consciousness that it is doing positive injury.

Some trees, as the oak, Spanish chestnut, and larch, which have very hard and durable heart-wood, are much less injured by cutting off large boughs than others, such as the beech, birch, ash, sycamore, &c., which have it soft and liable to decay. In the former the new wood is formed and grows over the wound before serious decay sets in, but in the latter decay

goes on so rapidly, that long before the wound is healed and covered over with the bark, a cavity is formed of such size that healing is beyond all power, and the only matter left for consideration is how best to prevent the total destruction of the tree,—a circumstance which, though elsewhere explained, may be here repeated as the process of filling or anointing the wound with vegetable tar, or oil of tar, sometimes termed creosote, which latter is of all appliances the best.

CHAPTER VI.

GAVIN CREE'S SYSTEM OF PRUNING.

NATURE, it is true, performs her own work unerringly, and so far as relates to natural productions she does, unaided, all that is required or desirable better far than by the assistance of art. In the culture of forest-trees, however, which are produced for purposes of art and industry rather than natural objects, the aid of art is called in to direct, or it may be to subvert, the ordinary course of nature. Wide and different opinions, however, prevail, both amongst theorists and practical men, as to how much, and what part, art should be called upon to perform in the culture of forest-trees, or how far nature should be allowed to take her own course undisturbed; it becomes the more necessary, therefore, to point out carefully the various results of the different modes of pruning, the various species of coniferæ, and leave those specially interested to judge for themselves which course to adopt.

Between forty and fifty years have now elapsed since pruning conifers was first practised in this country, if not upon a gigantic scale, at least sufficiently varied and extensive to allow those who wish instruction upon the subject to witness, learn, and judge for themselves as to results. The pruning referred to, as

performed about fifty years ago, was done by or under direction of the late Mr Gavin Cree, nurseryman, Biggar, and extended to all parts of the United Kingdom. His system at that time met with very general acceptance, was adopted and recommended by some of the most intelligent landed proprietors of the day, and he therefore earned for himself no small share of fame. Mr Cree's system, like most others, contained much that was commendable, but the little that was *wrong* in it was more than sufficient to neutralise all the good.

The following is a brief outline of the system practised by Mr Cree, which it is necessary to give before pointing out the sad results; but very few, it is presumed, will at all anticipate, even after listening to the theory, what the practical results were. The following are his own words in regard to it:—

"The common sap having extended over all the branches, mingles with the fluid absorbed by the leaves, and losing the watery and aeriform principles which are useless for nutrition by evaporation, it returns down the vessels of the bark, and in its course deposits cambium, which forms the annual rings of wood, then extends to and strengthens the extremities of the roots, whereby they are made to extract more nourishment from the soil throughout the season; and as the two saps commingle in the leaves, the descending sap, which has not been deposited, in like manner mixes with that extracted by the rootlets, and is again carried up with the ascending sap.

"How to economise these fluids for the advantage of the tree is to be considered. It is obvious, then, that when the upper lateral branches are shortened to half the length of the leading stem, and the others

proportionally, the sap has less superficies to cover than when they are allowed to extend to an improper length and thickness; in consequence, there is a greater supply for every part of the tree.

"The branches which are shortened always remain slender, by reason of the small superficies of the branch; and the rapidity with which the sap moves, very little of it is retained by the branch, and, of course, nearly the whole is deposited in the body of the tree. This truth, with the fact that the foliage remains nearly a month longer on the trees so shortened than on others, accounts for the wonderful rapidity of growth effected by this method of pruning. The smallness of the branches is of advantage likewise when it is necessary to prune close to the stem, as the wound made by that operation is proportionally small, and may be expected to cicatrise in the course of three years.

"It may be worth remarking that, if the branches are properly shortened, trees never become what is termed hide-bound. Even mismanaged trees, on which a dryness of bark has occurred, may be brought to a proper condition in the course of three seasons. In cases of this kind, the distance from the body at which the branches are amputated must be regulated by the size of the tree—the larger the tree the greater the distance.

"It has been found, experimentally, that trees under 18 feet in height and 15 inches in circumference, advance, taken averagely, as much both in height and circumference in six years, if the branches are properly shortened, as they do in fifteen, if these are not shortened, or are improperly pruned. The more trees are pruned close up to the stem before they are 18 feet

high, their growth is proportionally retarded. Trees pruned close to the stem, when the circumference at the part is under 15 inches, take in damp, so that the tree, if dissected after a certain period at the part where the branches have been cut, will be found black into the pith. This department of pruning, when improperly managed, is the principal cause of rot, more particularly in the larch. The reason is, the wood in young trees is more open in texture than older ones."

With a belief in what Mr Cree holds as truth, short experience, and limited practice, no marvel that he and many others went astray in the practice of pruning, especially conifers; and what has been but too justly charged against Pontey in regard to ruining the English woods, may equally be charged against Cree in ruining those in Scotland—with this difference only, that the former was done upon a very extensive scale, while the latter was but comparatively limited.

Having had frequent opportunities of witnessing the baneful effects of Cree's system of pruning coniferæ, it may be well to describe what some of the results are, after a lapse of fifty years. It may be repeated that his practice was to cut off one-half the length of all the branches from root to top of the tree, which, as he informs us, made their growth much slower than before, and kept the branches in all future time slow of growth. In this the theory and practice but too cordially agree; for the branches, after being cut, cease to grow to any appreciable extent for several years, and seldom, if ever, resume their former vigour.

This being the case with the branches, it becomes a very important inquiry how the stem of the tree is

thereby affected; and it need scarcely be explained that just in proportion as the growth of the branches is retarded, so is that of the stem. It is found, on dissecting any trees thus pruned, that the zones or annual rings become very considerably thinner from the time of the operation. So visible is this, that on examining a section of a tree severely pruned, it can be well ascertained what year it took place; and one observable feature is, that the zones are rarely so much affected the first as the second and subsequent years, showing that the injury is not experienced all at once, but by degrees, modified no doubt by various circumstances, such as shelter, condition of soil, age of trees, &c. The object aimed at in reducing the branches, Cree informs us, is to lessen the superficies which the sap has otherwise to cover in the structure of the branches; hence a greater quantity is allowed to go to build up the stem.

It appears scarcely necessary to state, much less to prove, that this theory is completely false, which is easily known from the fact that the branches are the chief laboratories or manufactories of the sap; hence, if the laboratory or manufactory is in any way injured or destroyed, that which it produces must be correspondingly influenced in an unfavourable way; if the branches which perform so important a part in forming the sap are cut off, the current is thereby diminished, and the whole structure of the tree suffers. Pruning, therefore, cannot increase in a direct way the quantity of wood in trees, either conifers or hardwoods, neither has it a beneficial effect either upon grouped plantations or those trees standing singly and exposed. Branches not only assist in elaborating the sap, but are the principal elaborators, whence it returns

to every part of the tree in the form of cambium; but they evidently exercise a very powerful influence by attracting sap and nourishment from the soil through the roots, which every other part of the tree benefits by in its general upbuilding: and this is carried on just in proportion to the number, health, and condition of the branches upon the tree.

Mr Cree speaks of the advantage of the foliage of a pruned tree remaining longer green in autumn than that of one not pruned. This is quite an error, for the sooner the better a tree matures its growth and defoliates its leaves; and if it does not do so before frost overtakes it, the results to the young shoots, as any one knows, are quite disastrous, and which are but too often the subject of lament.

CHAPTER VII.

THE FRENCH SYSTEM OF PRUNING.

A TREATISE, emanating from a high authority,[1] and from a quarter whence many foresters are looking for light and guidance in tree-culture, induces us to give the following extracts at considerable length. The translation from which we now quote was published in the 'Journal of Forestry,' October 1881, December 1881, January 1882, and February 1882, where it can be found *in extenso*, and should be read through, more, certainly, for its *warning* than as a guide and example to *imitate* and *follow*. The leading feature of the subject is its recommendation to prune close to the trunk, small and *large* limbs alike, and to dress the wounds with coal-tar.

What surprises one in this recommendation is the circumstance that we have placed before us great and numerous illustrations, hideous enough to alarm and warn any one against the very practice recommended. Suffice to say that we condemn, in the most emphatic manner, the whole practice of cutting off large limbs with a view to improve timber trees thus recommended and illustrated by the figures before us.

[1] Translated from the French of A. des Cars, by Charles S. Sargent, Professor of Arboriculture in Harvard College, U.S.

The theory is plausible enough, and perhaps in that lies the greatest danger; but the whole results of the practice cannot be too severely denounced as barbarous in the extreme, and it is only to be wondered at that in passing through so many intelligent men's hands in the 'Journal of Forestry,' it was not more severely criticised than it was.

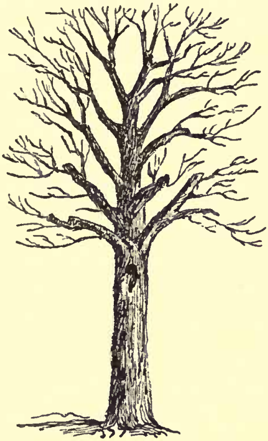

Fig. 10.

Fig. 10 is an illustration of what the French regard as a model tree for pruning, and to which, it is presumed, they wish all trees to conform. Fig. 11 is a tree denounced by the French arboriculturist as injudiciously pruned, *and no one will be in any way surprised at it being so denounced.* But when we are

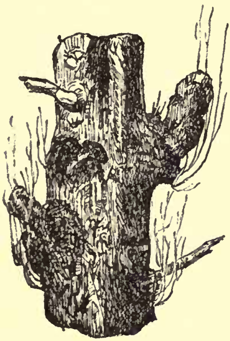

Fig. 11.

Fig. 12.

Fig. 13.

invited to look at fig. 12—the same tree when it has undergone what the French terms proper pruning

—we are simply shocked, and breathe the fervent petition, "Save our trees from the French and the French system; if this is it, let it be no more heard of." Fig. 13 is an illustration of scientific French pruning which speaks for itself in language not easily to be mistaken, and which, it is hoped, will be a warning against all such practice in all time coming.

For example, the writer says:—

"The appearance of many trees, their trunks covered with gaping wounds, protuberances, and the stumps of dead branches, clearly indicates that they have received careless or ignorant treatment. It is evident, even to persons little familiar with the art of sylviculture, that such trees are decayed to the heart, and of little value for industrial purposes. The number of trees thus affected is very great, and the annual aggregate loss to the community from the bad management to which trees are everywhere subjected is enormous. Such a condition is the result generally of entire neglect of pruning, or often, perhaps, of an unnatural, and therefore improper, system.

"The idea of increasing the productive capacity of forests by systematic pruning is not a new one; no process of sylviculture has been more often discussed.

"A more serious objection to pruning, which is often made by timber dealers—the persons perhaps most interested in the matter, and therefore most competent to judge—is that trees which have been pruned lose by the operation 25, 30, or even 50 per cent of their value—that is, a quarter to a half—and that such trees are generally decayed. This cannot be denied; but it proves that such trees have been badly pruned, not that all pruning is bad. Opponents of

pruning maintain, too, that the scars which such operations must leave on the trunks of trees indicate internal defects in the wood, and that these trees cannot be readily sold. This objection is also well-founded, in view of the manner in which the operations of pruning are generally performed; but it is the method which is faulty, and such objections must disappear before more scientific and rational treatment.

"A system of forest management which discards pruning is disastrous, and even if it were less so, would have many practical objections. A tree left entirely to itself generally develops in one of two directions. It does not grow upwards, and assumes the low round form common to the apple-tree; the lower branches grow disproportionately large, and absorb too much sap, to the detriment of the top of the tree; and these long heavy branches are often broken by the wind, or by snow and ice, leaving hideous stumps. Trees of this form are very common; they generally decay at the top before reaching maturity, and have little commercial value. On the other hand, many vigorous trees grow disproportionately at the top; the lower branches die from insufficient nourishment, fall off, and leave, when large, bare decayed spots, which gradually penetrate to the heart of the tree, and ruin also its commercial value.

"Wounds caused by the breaking off of large branches by wind or snow produce the same results. There is no remedy for the dangerous effects of such accidents except in pruning: it is a simple question of surgery. Without pruning the tree must sooner or later decay; with pruning, its value may be preserved.

"The secret of obtaining a complete cure in all operations requiring the removal of a branch, either

living or dead, consists in cutting close to and perfectly even with the trunk. Many authorities have hinted at this, the cardinal principle of all pruning; but M. de Courval first clearly demonstrated its importance, while his discovery of the value of coal-tar, or the refuse from gasworks, as a covering for wounds made in pruning, renders the application of his rule in all cases entirely safe.

"It follows that a wound caused by the amputation of a branch must, in order to heal properly, be made perfectly even with the trunk, that every part of its outer edge may be brought into direct communication with the leaves through the network of cells destined to convey the descending sap. Although this theory rests on one of the most elementary principles of vegetable physiology, it has not been applied before to practical forest management. The amputation having been made, even with the trunk in the manner explained, new wood will soon appear, forming first round the top and sides of the wound, which is soon completely surrounded by the new growth; the wound is gradually healed over, and the decay of the trunk prevented. The time required for the complete healing of a wound depends, of course, upon its dimensions and the natural vigour of the tree.

"The principle being established that large wounds can be made without injury to the tree, if care is taken in the manner indicated to prevent decay, it is easy to show the advantage of cutting off injured branches of any size. It is preferable to avoid, of course, the necessity of making large wounds, by properly pruning trees when young. All foresters agree that trees should be trained when young; but De Courval has amply demonstrated, by numerous

remarkable specimens exhibited at the Agricultural Show of Paris in 1861, and at the Universal Exposition of London in 1862, that it is beneficial and often indispensable to prune the oldest trees, if care and judgment are used in the operation. He has clearly shown, too, that trunks so treated attained a larger size and a greater value in a given time than those which, under similar conditions of growth, had been allowed to retain all their badly-placed branches.

" Each amputation of a branch produces a cavity, and the tree soon becomes entirely decayed. In view of such destruction, it might seem, perhaps, that branches of a certain diameter cannot be safely amputated. That this is an erroneous idea will be easily seen ; and it is only necessary to make the amputation even with the trunk, and then cover the wound with coal-tar, to avoid all bad results. Although wounds caused by the amputation of small branches heal over in spite of the faulty methods of pruning generally employed, such operations are, nevertheless, attended with considerable danger to the tree.

" If it can be proved that the number of timber trees may be doubled in a plantation by good management, and that the value of individual trees scattered through the fields and along the roadsides may be wonderfully increased, it is easy to understand that a landowner may greatly benefit himself, and add to the wealth of his country, by adopting such methods.

" That pruning can accomplish the results which are claimed for it, is found in the fact that trees treated by the rational system proposed grow more vigorously, and retain their foliage longer than unpruned trees in the same locality grown under similar conditions.

"*Classification of Forest-Trees according to age.*—The technical names by which reserve trees are known vary in different regions. For our purpose it will be best to divide the life of a forest-tree into four principal periods, designated as follows :—

1. Young, up to about forty years.
2. Middle-aged, from forty to eighty years.
3. Old, from eighty to one hundred and fifty years.
4. Very old trees, whose number is rapidly diminishing, may be called veterans.[1]

"These divisions are not, of course, absolute, as it is often difficult to determine, even approximately, the age of a standing tree; and the forester must use considerable judgment in the application of the following rules :—

"1. The head of the young tree should be egg-shaped or elongated oval, and well balanced on the trunk, which should not exceed a third of the entire height of the tree. The lower branches should be sufficiently shortened to check their excessive growth at the expense of the leader, without, however, being so reduced as to impair the vigour of growth of the tree.

"2. The head of the middle-aged tree should form an oval less elongated than that necessary for trees of the first class. The height of the trunk should equal one-third to two-fifths of the height of the tree.

[1] "The technical terms employed in France to designate trees of the four classes into which forest-trees are generally divided—*baliveau*, *moderne*, *ancien*, and *vieilles écorces*—have no equivalent as yet, and are not well translated into English. The term *baliveau* is also sometimes applied to reserve trees of any age left after the first cutting of a plantation, and such trees are then called *modernes* or *anciens*, according as they have been allowed to remain after a second or third cutting of the coppice."—C. S. S.

"The head of the old tree should be gradually rounded in outline; the trunk may, in some cases, be made to reach a height equal to half the height of the tree, which has now probably ceased to grow upwards.

"4. *Veterans.*—Trees classed as veterans have generally ceased to increase in size. They gradually become flat-headed and spread out, without, however, greatly injuring the adjoining coppices and plantations destined to take their places.

"It is well to remember that the forms recommended are those nature gives the most perfect and most beautiful trees; although it is the economic and not the picturesque aspect of trees which is here under consideration.

"*Sap-Lifters* (fig. 13, p. 267).—The name sap-lifter (*branche d'appel*) may, for want of a better term, be given to the branch or branches retained at the end of the shortened main branch. The name indicates the object for which such branches are left—namely, to attract and elaborate, by means of their leaves, a sufficient flow of sap to ensure the growth of the branch. Sometimes the main branches are so long that it is impossible for the operator to reach the ends where the sap-lifting branchlets should, of course, be left. In the case of the oak, such branches, except for the appearance of the tree, are of little importance; and provided the main branch retained is of a certain length (10 or 12 feet), and if it is large and on a large healthy tree, a sufficient number of new shoots to ensure vigorous growth will soon appear. With the beech, however, and some other trees which do not develop shoots from dormant buds as freely as the oak, it is necessary to cut the branch just above the forking of another branch or

branchlet large enough to attract sufficient sap to ensure a healthy growth.

"*Double or Forking Branches.*—In the case of a double branch, or of a branch forking close to the trunk of the tree, one of these branches should always be removed, that the base of the branch may not become disproportionately large. If, however, such double branches are objectionable near the trunk of the tree, they are of great importance at the extremities of main branches; and whenever it is possible branches should be shortened in such a manner as to secure forking branchlets at their ends.

"*Use of Coal-tar in dressing Wounds.*—All wounds made on the tree in pruning should be covered with a coat of coal-tar, applied with an ordinary painter's brush.

"The importance of observing the directions which have been given, however trivial or unimportant they may seem, will be apparent when it is understood that the entire success of the operation of pruning, and of the future production of timber, depends on the proper application of these rules.

"It should always be borne in mind that a cut perfectly smooth, and as closely following the line of the trunk as circumstances will permit, is soon recovered with healthy straight-grained wood. In this connection it is well to quote from De Courval, who speaks with the authority of experience, and who has shown with many varieties of trees the correctness of his statements. 'A casual examination,' he says, 'will show that between the surface, which has been cut smooth and treated with coal-tar, and the new tissues which soon cover it, there is only the thinnest crack or fissure analogous to the natural cracks or openings

which always appear in wood in seasoning, and which, as is well known, do not diminish its strength, elasticity, or value for all industrial purposes.'

"*Old Trees.*—It is hardly necessary to explain that old trees require more cautious treatment than younger ones, which may, if necessary, be entirely remodelled. In pruning an old tree it is not a question of a leader or of increasing the size; and it is only desirable to regulate the shape of the head somewhat, by shortening when necessary such branches as interfere, by their length or position, with the equilibrium of the tree itself, or injure other trees in its vicinity. The heads of old trees should, as far as possible, be reduced to a more or less rounded ovoid, the lower branches being the shortest.

"The main branches should be left 6 to 12 feet long, or even longer if they are furnished with sufficient shoots to regulate the flow of sap—although it may be well to repeat that the branches of the beech should not be shortened, unless it can be done in such a manner as to ensure, by abundant foliage at their ends, the supply of sap necessary for the regular development of the tree. In shortening branches it is difficult, especially for beginners in the art of pruning, to determine the point at which the operation is best performed. Practice and experience soon teach this, however; and even if a few branches die under the operation, no very serious damage has been done. Two or three large branches can be safely removed at one time from old trees; and although it is not desirable to make many wounds on the trunk of an old tree, they are less injurious than dead and decaying branches, which produce cavities in the trunk that should be avoided at any cost. The branches of an

old tree should not be allowed to interfere with the growth of a younger tree standing near and intended to replace it. In cases of this sort the branches of the old tree should be cut in on the side nearest the young tree much more severely than if it stood by itself.

"*Veterans.*—If a tree of this class has been properly managed, the length of the trunk should equal one-third to one-half of its entire height. The method of pruning very old trees does not essentially differ from that recommended for trees belonging to the last class. All dead or dying wood should be carefully removed, and all old wounds not covered with a healthy growth of new wood should be reopened in the manner to be explained hereafter. All branches either disproportionately long or which might interfere with neighbouring trees should be shortened; and should it appear advisable, one or two of the lower branches may be amputated. This can always be done without injury to the tree, and has the advantage of increasing the length of the trunk and stimulating the growth of the top of the tree. A tree is never so old that pruning, if practised with judgment and skill, cannot prolong its life and increase its value.

"The restoration of an old oak may be cited in this connection. This tree (fig. 11, p. 267), which stood in a hedgerow, was probably two hundred years old, and had suffered terribly from neglect and mutilation. The lower portion of the trunk was covered with the dead stumps of branches, their numerous protuberances being filled with cavities and bristling with vigorous shoots. The top had begun to decay, and the tree seemed destined to speedy death. In pruning this tree (see fig. 12) it became necessary to make, in the

space of a few feet, no less than seven wounds, 10 to 20 inches wide, in addition to many others of smaller size. In spite of this heroic treatment the tree improved remarkably in health and vigour; and the numerous wounds made on the trunk by the amputation of dead branches entirely healed over." *This is pure fiction, and entirely at variance with facts.*

"It must be acknowledged that, had this oak been left in the condition to which neglect had reduced it, or if nothing beyond lopping off from year to year the young shoots developed along the trunk had been attempted, its decay would have been rapid and complete; without pruning it must soon have died without yielding anything more valuable than firewood.

"The removal of numerous branches, for the purpose of restoring vigour to a decrepit tree, may seem opposed to what has already been stated in regard to the functions of leaves in elaborating plant food; and it might be argued that pruning must be injurious, because, in shortening or removing a branch, some of the leaf organs essential to the growth of the tree must also be destroyed. Such an argument is based on a popular error of very general acceptance.

"*Loosened Bark.*—It is necessary to frequently examine the lower portions of the trunk, especially of trees beginning to grow old; for here is often found the cause of death in trees, in the large sheets of bark entirely separated from the trunk. This condition of things, which often cannot be detected except by the hollow sound produced by striking the trunk with the back of the iron pruning-knife, arrests the circulation of sap, while the cavity between the bark and the wood furnishes a safe retreat for a multitude of in-

sects, which hasten the destruction of the tree. The dead bark should be entirely removed, even should it be necessary in doing so to make large wounds. Attention, too, should be given to injuries to the bark caused by the fall of neighbouring trees. These may remain hidden for years, and are often only detected by the peculiar sound produced by a blow of the pruning-knife.

" *Cavities in the Trunk.*—Very often, when a tree has been long neglected, the trunk is seriously injured by cavities, caused by the decay of dead or broken branches. It is not claimed that pruning can remove defects of this nature: it can with proper applications, however, arrest the progress of the evil, and in such cases should always be resorted to. The edge of the cavity should be cut smooth and even, and all decomposed matter, or growth of new bark formed in the interior, should be carefully removed. A coating of coal-tar should be applied to the surface of the cavity, and the mouth plugged with a piece of well-seasoned oak, securely driven into place; the end of the plug should then be carefully pared smooth and covered with coal-tar, precisely as if the stump of a branch were under treatment. If the cavity is too large to be closed in this manner, a piece of thoroughly seasoned oak-board, carefully fitted to it, may be securely nailed into the opening, and then covered with coal-tar. It is often advisable to guard against the attacks of insects, by nailing a piece of zinc or other metal over the board, in such a way that the growth of the new wood will in time completely cover it.

" These operations resemble, if such a comparison

is admissible, the fillings performed by dentists, and with the same object, to check the progress of decay.[1]

"*Season for Pruning.*—The most favourable season of the year for pruning is the autumn, when the days are still long and pleasant. The sudden and severe frosts, however, which often occur at this season of the year, are dangerous, and in some instances have a tendency to cause decay in freshly-made wounds. In winter the days are too short, and often too stormy, to allow continuous work of this nature; while the loss of sap which occurs when trees are pruned in the spring, although considerably checked by the use of coal-tar, is probably rightly considered injurious. The leaves interfere with pruning during the summer months, when, too, there is a danger of the workmen inflicting injury on the growing tender shoots of neighbouring trees; but a tree may be pruned at any season of the year, and the best time for pruning that which is most convenient, and when it can be most cheaply performed.

"All trees, whatever the nature of the soil in which they grow, may be advantageously and profitably pruned, with the exception, perhaps, of trees growing on very poor and barren soil. These, as a general rule, can produce nothing more valuable than fuel, and hardly justify the cost and labour of pruning.

"*The use of Coal-tar.*—Coal-tar, a waste product of gasworks, is a dark-brown imperishable substance, with the odour of creosote. It can be applied with

[1] If the wound or decay is there unprovoked and uninvited, certainly all should be done that can be done to check its progress; but no one would be justified in creating such wounds by cutting off large boughs if he could help it.

an ordinary painter's brush, and may be used cold, except in very cold weather, when it should be slightly warmed before application. Coal-tar has remarkable preservative properties, and may be used with equal advantage on living and dead wood. A single application, without penetrating deeper than ordinary paint, forms an impervious coating to the wood-cells, which would, without such covering, under external influences, soon become channels of decay. This simple application, then, produces a sort of instantaneous cauterisation, and preserves from decay wounds caused either in pruning or by accident. The odour of coal-tar drives away insects, or prevents them, by complete adherence to the wood, from injuring it. After long and expensive experiments, the director of the parks of the city of Paris finally, in 1863, adopted coal-tar in preference to other preparations used for covering tree wounds,—as may be seen in all the principal streets of the capital."

It is very remarkable that coal-tar is thus so highly appreciated and recommended for the preservation of wood, and preventing decay in wounds, when in reality it possesses no such preservative property. I have made repeated experiments with coal-tar, and all other wood preservatives, or at least most other, and have no hesitation in denouncing it as the very worst of all of them; indeed it is very questionable if it does not rather produce than prevent decay in wood. I am strongly of opinion it does; and if that impression is well-founded, woe betide the trees which are pruned, or rather mutilated, on the faith that coal-tar will heal the wounds, or at least preserve the old wood till the new covers it!

"*Objections to other Preparations.*—Efforts have

been made for a long time to discover some method of covering the wounds inflicted on trees, either accidentally or by the hands of man. The remedy usually recommended from time immemorial is the ointment of St Fiacre, a mixture of loam and cow-dung. Various preparations too, used in grafting, and having resin, wax, and grease as their basis, have at different times been very generally recommended for this purpose. These preparations are expensive; and as they must be applied hot, it is not practicable to use them on a large scale. Their use, too, is attended with serious difficulties. As the new growth of wood spreads over the wound, these thick coatings are either broken or pushed aside bodily, according to the power of resistance of the material used; and the wood is again exposed, and a safe retreat for injurious insects prepared.

"One coat of coal-tar is sufficient for wounds of ordinary size; but when they are exceptionally large, a second coat may, after a few years, be well applied. In warm countries, like the south of France, the great heat of summer renders coal-tar so liquid that it is often impossible to properly treat wounds made at that season. In such cases another coat should be applied during the following winter.

"*Effects of Coal-tar on the Elm.*—The effect of coal-tar on the elm is not always as satisfactory as upon other forest-trees, such as the oak, ash, sycamore, birch, maple, &c. The application of a coat of coal-tar on all of these gives at once to the wound a hard firm surface; on the elm, however, it does not always adhere firmly, owing to the formation on the surface of the wound of the water-blisters common to this tree. In such cases the coal-tar which does not ad-

here firmly should be rubbed off, and another coat applied to the wound.

"*Conifers.*—These trees, which are generally gregarious and form extensive forests, are valuable subjects for sylviculture, on account of the readiness with which they reproduce themselves from seed, and because they admirably prepare the soil to produce hard woods, and especially the oak. Of the two operations of pruning—the cutting close to the trunk and the shortening of branches—the second need not often be applied to the natural pyramidal form of firs and spruces; for these trees nothing is necessary beyond removing, when possible, dead or dying branches.

"The pines, however, when not growing under the conditions peculiar to them—that is, crowded together—often develop enormous branches, which greatly interfere with the beauty and the value of the trunk, the only portion of the tree possessed of any value. The rules laid down for shortening the branches of oaks and other deciduous trees are, in case of necessity, applicable to pines—that is, one-third or one-half of the length of the branches may be safely cut away. It is essential, however, to preserve at the end of the shortened branches an abundant supply of foliage, as the branch of a coniferous tree deprived of leaves is more certain to perish than the branch of a deciduous tree under similar circumstances. A pine may in this way be made to assume the natural form it would have had if grown under normal conditions; the trunk lengthens and thickens regularly, giving to the tree an economic value for many purposes of construction, and especially for the masts and spars of vessels."

With all due respect to what the French think and

say in favour of coal-tar, it is, after all, one of the very worst appliances for preserving wood and preventing decay. I have made several experiments with it, and bestowed much attention to its preservative properties, and if anything I am more and more confirmed in the fact that coal-tar should not be used for the purpose here recommended, but vegetable-tar should be used instead, or creosote, which is extensively employed for the preservation of railway sleepers; and in the absence of these, oil of any kind, turpentine, or alum in solution. It is also to be hoped no one will venture to cut off from the bole of an old tree a limb of any kind, under the impression that the wound can be healed and the tree left in as good a state as before. Let the advice, repeatedly tendered throughout this book, be listened to, not to prune any branch from a tree unless absolutely necessary and cannot be avoided; and withal to rest fully satisfied that in any case the tree, as a timber tree, is rather injured than benefited by the practice of pruning large limbs or heavy branches.

CHAPTER VIII.

EXPERIMENTS IN PRUNING.

FINDING that pruning diminishes, or at least prevents, the increase of wood in proportion to the quantity of branches removed, the writer has devoted considerable time and labour to find out, as far as possible, what proportion of branches a well-balanced tree ought to have, in order to make wood, at the most desirable and satisfactory rate, neither too hard nor too soft, too fast nor too slow grown; and in order to do this, he took along with himself two practical foresters, and went into an extensive natural forest as well as into several plantations, and selected choice specimens of larch, Scots pine, and Norway spruce. In making the selection, some trees were chosen which were considered perfect in all their parts and proportions; some, again, that were thought to have too few branches, some too tall in proportion to their girth, and others too thick for their height. These conditions, be it observed, were unanimously agreed upon, and written down before the tree to which they referred was cut, pruned, dissected, and weighed. The other details were added, as shown in the subjoined table.

The annexed table will illustrate the conditions under which true forest-trees should be grown at their

particular stages of growth, and may assist in guarding the inexperienced against the many allurements which beset them in regard to pernicious pruning.

Species of Tree.	Age of Tree.	Entire Height of Tree.	Girth near the Ground.	Girth at Centre.	Weight of Stem.	Weight of Branches.	Total Weight of Stem and Branches.
	Yrs.	ft. in.	in.	in.	lb. oz.	lb. oz.	lb. oz.
1. Norway spruce,	15	8 7	8 0	4¼	6 0	11 4	17 4
2. "	10	13 10	13½ 0	7½	18 0	27 8	45 8
3. "	10	13 3	12 0	7	14 8	28 8	43 0
4. "	10	8 9	7½ 0	4½	4 0	7 4	11 4
5. "	10	10 11	9½ 0	5	7 0	14 14	21 14
6. "	10	12 6	11 0	6½	11 0	21 0	32 0
7. "	10	9 0	8 0	4	4 8	10 0	14 8
8. "	10	10 0	7½ 0	3	4 12	9 12	14 8
9. "	10	10 2	8 0	4½	12 0	20 0	32 0
10. "	7	4 3	5 0	2	2 4	2 0	4 4
1. Scots pine, . .	10	12 1	12½ 0	7	17½ 0	19 0	36 8
2. "	10	13 10	14 0	6½	24 0	25 4	49 4
3. "	26	20 4½	22 1	9⅞	84 5	84 5½	168 10½
4. "	20	15 5½	13 0	5	14 12	14 0	28 12
5. "	36	27 5	30 0	13½	224 8	171 9½	395 1½
6. "	26	22 5	23 0	11	84 8	28 9½	113 1½
7. "	38	31 0	27 0	19	238 0	84 9	322 9
8. "	36	30 2	46 0	23½	592 0	444 8	1036 8
9. "	19	23 0	26 0	12	126 0	99 0	225 0
10. "	7	4 5	5¼ 0	2½	2 0	1 4	3 4
1. Larch, . . .	15	20 6	19 0	10	52 4	21 6	73 10
2. "	15	20 5	17 0	9	41 0	37 2	78 2
3. "	15	10 10	11 0	6½	12 2	6 12	18 4
4. "	10	13 6	11 0	6	10 4	10 0	20 4
5. "	10	12 4	10 0	5½	8 4	7 12	16 0
6. "	10	13 3	13 0	7	16 0	9 12	25 12
7. "	19	27 0	20 0	10	91 0	25 0	116 0
8. "	10	16 0	14 0	6	29 0	20 8	49 8
9. "	10	13 6	14 6	6	23 0	18 0	41 0
10. "	7	4 4	4 0	1½	1 8	0 12	2 4

After a fair inspection of each tree in all its parts, and especially of the annual concentric rings by which the annual deposit of wood is known, it was found that the general defect was too few branches, and that it was difficult to find trees in masses sufficiently clothed to meet the requirements of a perfect tree. It is quite apparent, which can be seen in any piece of dressed and polished wood, that where the zones or rings exceed one-eighth of an inch in thickness, it is

coarse in the grain, knotty, and of inferior quality—the knots being so large that, in the case of small scantlings, they are liable to break and unsafe in most parts of a building, and as deals, often still more objectionable. For many descriptions of woodwork, where large scantlings, beams, lintels, pillars, and posts are required, it matters little how coarse and knotty the wood is, and in point of durability of knots the more the better; but it nevertheless remains true that, for a lot of fine-grained wood, clean of knots, straight and tall, very much higher prices are realised than for coarse descriptions. From these and various other considerations the conclusion arrived at is, that it is injudicious to grow wood (pine and fir) at a rate exceeding one-eighth of an inch of zone annually, and that, in order to maintain this condition of growth, the branches must be so regulated as to ensure it by thinning or pruning, gently or severely, frequently or seldom, as the case requires.

It was further observable, in dissecting the trees, that those considered nearest perfection in symmetry, balance, &c., were those that girthed at a little above the swell of the root as many inches as the whole tree measured feet in height.

In the experiments made, it was still further observable that the necessary amount of branches required for the proper and full development of each individual tree was about equal to the weight of the stem. The figures in the table do not show this conclusively; but those trees that really pleased the eye and satisfied the mind, as being the best and most proportionably grown, bore the above proportion very closely. In order to maintain weight for weight between stem and branches the latter require to be preserved; nor should

the vitality of the lower branches be much checked so long as thinning is continued or required, which should rather be under than over thirty years' growth.

Seeing, therefore, that coniferous trees require to be superabundantly clothed with branches, covered indeed to the surface of the ground during the first fifteen years or so of their growth, and only partially checked during the next fifteen, it becomes the question, What has pruning to do, or is required to do, in promoting their growth ?

I have seen and examined many thousands of acres of coniferous plantations in various parts of the kingdom, but have never met with one of which it could be said the trees had too many branches. On the other hand, I have seen, and see almost daily, plantations much in need of them. If a pine or fir plantation is in such a state as to require pruning, no further proof is wanted to show that the crop is too thin upon the ground to be good and profitable, and pruning, which is only another form of thinning, would aggravate rather than diminish the evil. So far, then, pruning of coniferous plantations in general has been shown to be objectionable, nor is there any compensating benefit imparted to the tree through the process.

CHAPTER IX.

ORNAMENTAL PRUNING.

The outline, structure, and general character of a purely ornamental tree are determined almost entirely by the taste of the grower, or those whom its appearance is to gratify and please. One person likes a close compact tree, and sees a special beauty in it; another admires an airy, loose, flowing character, and most admires it; a third perceives only charm and delight in an irregular, sharp, and unique outline; others, again, are only pleased with the quaint, irregular, and romantic form; while yet another class admires the curious, fantastic, and grotesque. The pinetum of any considerable extent usually contains coniferous specimen trees of all sorts, and such as generally please the various tastes of individuals. The first class is charmed with such species as the *pinsapo* fir and the Chilian *arbor-vitæ,* to which, to their taste and liking, no tree is to be compared.

The kind of pruning these species generally require is attention to the leader, and preventing any lateral branches from extending beyond the prescribed limits; and those whose taste runs in this direction usually prefer the *pinsapo* fir to be pruned and trained as a cone or pyramid; and if not subjected to an over-

rigid process, it forms, in the estimate of many whose taste is not to be disregarded, a most delightful object. Those who like a more airy, light, and flowing character of tree, will find it in the *Pinus lasiocarpa* or woolly-scaled silver fir, common larch, *P. monticula*, Weymouth pine, &c. Pruning, and indeed any culture, is little required in this class, just because the taste is less rigid and exacting, and less required; and except it be to relieve the tree of any irregular branch that does not conform and harmonise with the general structure to give direction to the leader, or remove dead and diseased branches, nothing further is required or should be done. The taste of the third party is most pleased with the cedar of Lebanon, Atlas cedar, common silver fir, araucaria, &c. Pruning here, again, can do little to improve the tree in its points of admiration, as its irregularity constitutes to them its main feature of attraction. Double leaders, however, and such limbs as are liable to split from the tree by winds, lodgments of snow, &c., should so far be pruned as to render the risks less serious. The fourth class are usually most pleased with such trees as the araucaria, common yew, *Cupressus Lambertiana*, *Pinus insignis*, and suchlike. Admirers of this class, again, rarely desire to see any pruning done, as with them any irregularity is a mark of beauty, or at least a point of admiration; and it has to be admitted that, when beauty or rather delight is seen in an irregular branch, it must be a wrong thing to those whom it pleases to denude the tree of such, and obliterate that feature in the tree which, of all others, affords them most pleasure and delight. Pruning may, however, even here be admissible; for there are few trees so grown that one branch may not override another and gall its bark, or a limb project at

such an acute angle as to form between the surfaces of the bark a false connection, and such as will ultimately end in the two separating and doing irreparable damage to the tree.

I have indicated in a very general way the kinds of preferences which different classes of individuals have for different species and descriptions of trees, but we have yet to notice that while one person has a special preference for one species and character of tree, it by no means follows that he has no appreciation of other trees. There are individual exceptions to this rule, but the general rule undoubtedly is, that while one individual has a particular species or character of tree he admires and prefers to all others, he yet appreciates and finds delight in many others. A well-balanced mind is usually so constructed as to appreciate any natural product, and specially all kinds and descriptions of trees; while there are enthusiasts who go heart and mind into certain special subjects, and such men not unfrequently make discoveries in certain directions which less enthusiastic men would overlook, from the simple circumstance that the latter neither look long enough nor intensely enough in the one direction. Each individual tree should be grown in every way suited to its character, and specially in accordance with its natural habits. No person, for example, would think it judicious to prune a *Picea pinsapo* in a manner similar to the *Cupressus Lambertiana*, or treat an araucaria as he would a *Wellingtonia gigantea*. One thing, perhaps, more than any other, has to be considered in regard to ornamental tree pruning—namely, the exposure in which they are grown. We have found it quite necessary to shorten the extremities of the branches of the *Abies Douglasii* in freely

exposed situations, whereas in sheltered sites the defect was that their branches spread too little.

An ornamental tree, especially in its young state, should be fairly and evenly balanced, and equally rooted on all sides: this is not a mere matter of taste, but a *sine qua non* in all tree-culture, for unless duly attended to in youth, in old age it often suffers to destruction and premature extinction. In the culture of ornamental trees, the production of perfect individual specimens ought to be the primary object, and if this were so, then there would be something as a rule for pruning; whereas, without such object in view, there can be nothing to guide and direct in the work but fancy, wild or tame, as the case may be. As an illustration of this, a lady said she did not like the larch, either young or old, because when young, as well as old, it was naked and bare in winter, and in mature years it lacked that rounded cloudy top so admirable in the Scots fir (the native Highland pine of Scotland).

Gilpin, in his 'Forest Scenery,' says in respect to the silver fir, "it is ugly in the extreme;" and he scarcely finds a place in the wide world sufficiently unworthy of it. Now, with all deference to those who hold such views and sentiments, we venture to say that in its own place the silver fir is as grand and worthy a tree as the woodland can boast of, and over which the forest may with acclamation clap its hands.

Any one with a landscape picture before him of the native mountains of Switzerland will usually observe the larch as a prominent object, and its thin, sharp, spear-like tops, pointed, jagged, and weather-beaten, betoken the adaptation of means to ends; for in such exposures, with clouds of snowstorm and tempest to weather and outlive, no tree known to us would so

well endure. Bearing in mind, then, the natural characteristics of any individual species of tree, and what it is in its highest natural state of perfection, we ought in all our efforts at culture, whether of planting, thinning, or pruning, to seek that attainment, or as near an approximation to it as possible.

Many individual trees may never need any correction at all. But there is a large class of the choice ornamental coniferæ belonging to the genera *cupressus*, *thuja*, *juniper*, and *retinospora*, which are much benefited by annual pruning. They have all a greater or less tendency to form a multiplicity of leading shoots, which generally, in the long-run, leads to their becoming unequally balanced and irregular in shape, and made up of many weak stems that are liable to break away under pressure of wind, heavy rain, or snow.

CHAPTER X.

INSTRUMENTS FOR PRUNING.

The chisel, which is made with a socket, is fastened upon a long handle by means of a screw-nail. The handle may be of any convenient length, from 8 to 20 feet, or upwards. The handle of the chisel, when sharply struck with a small wooden mallet, will cut even a large branch at a single stroke; and if the handle is perfectly straight, and fills the socket completely, the length of the handle does not diminish the force of the blow in any important degree.

What applies to the oak is equally applicable to the elm, ash, beech, lime, Spanish chestnut, sycamore, &c.; that is to say, any one of them may be pruned at any period of the year, except in cases where the plants require to be cut over close to the surface of the ground: in such cases we prefer doing the work either during the last week in March or first week in April; because, if a plant is cut over late in summer or early in winter, it is so long exposed to the wet as materially to retard, if not entirely to prevent, vegetation. The walnut, sycamore, maple, and birch, &c., we prefer pruning during the months of June, July, and August, when the sap is most active, and when the

solar heat has the greatest influence. The sun, during this season of the year, produces also a hardening influence upon the newly-inflicted wounds, which by this means are sooner healed up, as the bark then more quickly covers the wounds than if pruned at any other season of the year. In order to test the effect of so doing, we have pruned sycamore and birch during December, and have found them bleeding from the wounds during the succeeding April and May; but we have never found any injurious results from pruning during summer and early autumn. At that season of the year, when the sap-wood is maturing, there is least danger of spray being produced from the wounds, and equally little of the tree bleeding.

Any pruning performed upon the branches of coniferæ should be done during September or October, as during these months the fluids are in a more fixed state, and are not disposed to ooze out so freely as earlier in the season; and if deferred till winter, the wood being in an expanded state during frosty weather, a greater portion of it would become decomposed before the bark covers over the wound than if the operation had been performed in autumn. As regards the pruning of dead wood, the case is materially different, no wound being thereby inflicted in the vital part of the tree, and, consequently, the fluids remain undisturbed. One reason, however, for pruning off dead wood in spring and during summer, instead of during the colder months of the year, is in consequence of the tendency it has of lowering the temperature of the plantation: dead wood probably produces that effect more completely than any moderate degree of thinning could do. The benefit, however, arising from pruning off decayed branches from pine and fir timber is so great, compared

with the evils that can arise from it, that in all cases, when practicable, it should be adopted.

The averuncator is also sometimes used with advantage for similar purposes, but it is not so applicable in cutting off close contending leaders as the common pruning-chisel, nor yet branches over an inch diameter.

"The most convenient tools for pruning," says the French authority already quoted, "is the straight-bladed cleaving-knife. Success in all operations of pruning depends on the neatness of the cut, and this cannot be attained with the common bill-hook used in many parts of France. The best tool for the purpose is one which has been used for many years in Holland, and which has lately been improved by De Courval. It weighs from 2 lb. 12 oz. to 3 lb. 6 oz., or more, according to the strength of the workman. The blade is reinforced in the middle, to increase its strength and concentrate the weight. In the north of France, this tool is generally hung to an iron hook attached to a leather strap buckled round the workman's waist, who is thus left perfectly free in his movements.

"In pruning tall trees, or trees otherwise difficult to climb, the leather belt may with advantage be passed over the shoulder, thus bringing the pruning-knife under the arm in a position from which it cannot easily be dislodged in climbing. To ensure greater safety in climbing tall trees, a stout cord attached to the workman's waist may be fastened round the trunk in such a manner as to prevent, in case of accident, a dangerous fall. A hatchet is useful, and facilitates the operation of pruning; it may be used with one or both hands, and serves to lop off large branches, protuberances on the trunk, or the dead stumps of branches, which from their hardness would soon dull

the edge of the best pruning-knife. A saw, too, is very useful in cutting large branches, but it requires so much practice to use this tool skilfully, that it cannot be generally recommended.

"*Ladders.*—Each labourer should be equipped with a light ladder, proportionate to the height of the tree on which he is to operate, and broader at the base than at the top. De Courval recommends that the feet of ladders intended for this purpose should be pointed, to prevent them from slipping. This is a good plan, although hardly sufficient to prevent accident; and the top of the ladder should be fastened with a strong rope to the trunk of the tree, to prevent it from being thrown down by falling branches.

"*Hooks or Spurs.*—Except in very exceptional cases, or where very large trees are to be operated on, the climbing-spurs sometimes used by professional pruners should not be allowed. These men, paid according to the number of trees operated on or the quantity of wood cut, have no idea in pruning beyond cutting the largest amount of wood in the shortest time. Climbing-spurs should never be used by good workmen even in pruning young trees whose bark is not sufficiently thick to resist the wounds caused by the sharp iron teeth of this tool. Wounds made in this way encourage the growth of injurious side-shoots on the trunk, and leave defects in the wood which never disappear, and diminish its value.

"The future value of a tree depends upon the manner in which the operation of pruning has been performed; and the person to whom this work is intrusted should fully understand its importance. Unskilful or injudicious pruning may completely ruin a tree, and the difficulty of obtaining a labourer cap-

able of doing such work intelligently, causes, no doubt, many arboriculturists to completely neglect pruning of every kind.

"*The Dendroscope.*—The tree requiring pruning should be carefully studied from the ground, that the operator may be able to judge intelligently which branches should be removed or shortened in order to reduce it to the desired shape. This may at first seem difficult to beginners in the art of pruning; and a dendroscope, the name suggested for a simple little contrivance, may be here used with advantage. A

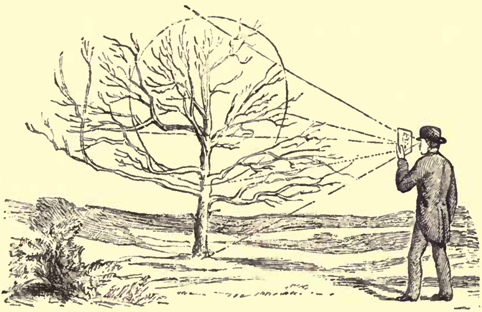

Fig. 14.

dendroscope may be made from a piece of thin board or cardboard (a playing-card answers the purpose), in which a hole, of the shape it is desired to reduce the tree to, has been cut. Across the middle of the hole, from top to bottom, a piece of fine wire is stretched to serve as a guide to the eye" (see fig. 14).

"Holding the dendroscope at the level of the eye, with the wire opposite the centre of the trunk of the tree to be studied, the operator approaches the tree until the bottom of the cut falls on the trunk at the ground-line. It is easy to see at a glance, with the

aid of this contrivance, what operations should be performed in order to reduce the tree to the desired shape.

"Remembering that under ordinary circumstances a vigorous, handsome tree must have a straight vertical trunk and an evenly-balanced head, the first object of pruning should be to produce these conditions. The head, as has already been explained, should be oval in form; the height of this, however, must depend on the size of the trunk and the age of the tree when first subjected to the operations of pruning.

"*Selection of the Leader.*—The branch most nearly perpendicular on the trunk of the tree should be selected to form the leader; and it may be stated as an absolute rule that whenever a branch near the top of the tree stands vertically on the trunk, or even on any part of the trunk, it should be preserved for the leader."

These directions being French, are worthy of careful consideration, and ought to be well considered before adopting them, some of which are doubtless worthy of trial, while others are not worth a moment's thought.

The first instrument used by the British forester is the common forester's clasp pruning-knife, by which mostly all pruning, so long as within reach of the hand, is done,—the great secret with which is to keep it thoroughly sharp, and use it only when and where required.

There is next the pruning handsaw, for sawing off such branches as are too strong to cut with the knife. The spokeshave is used to smooth over the rough surface and entirely obliterate the saw marks, after

which the wound is dressed with paint, vegetable-tar, creosote, or other suitable balsam for preserving the wood from decay.

We have next the pruning-chisel and mallet, for cutting off such branches as are out of reach of the hand, and especially such as are closely joined to the stem of the tree.

The averuncator is very useful for lopping off over-hanging branches upon rides, and carriage-drives, and walks, but it should not be employed for cutting branches mŭch over an inch diameter. The long- and short-handled bill-hooks are also very suitable for lightening heavy and protuding branches, but should only be employed for cutting loose and stray ones, and never such as grow close to the stem of the tree, for which purpose they are not well adapted.

There is also the pole-saw, a very useful instrument in its place, and is often of great service in cutting branches so situated that they cannot be approached by any other means.

CHAPTER XI.

RULES FOR PRUNING.

1. PRUNING may be regarded as the work which thinning, from some reason, has not overtaken.

2. Pruning is the work of some form of neglect, and that which renders it necessary is the circumstance that thinning was done at the wrong time.

3. Pruning is the work of art, and therefore should be done so as to conceal art.

4. No pruning should be done that can be dispensed with. It is either of great benefit or of much evil, for there is no neutral position for pruning.

5. The manner in which pruning is done indicates the taste, skill, and knowledge of forestry better than any other branch of the art.

6. No one should be allowed to prune, in the general and comprehensive sense, unless thoroughly conversant with the laws of physiology.

7. It is only saplings that pruning can truly benefit, and when properly done at that early stage of growth, it may do much real and permanent good.

8. Pruning dead wood off pine and fir trees requires very little artistic taste or knowledge, and is the simplest form of pruning.

9. Pruning or lightening branches overhanging

roads or fields is done not to benefit, but to some extent less or more to injure the trees, and therefore the object, apart from removing obstructions, is to do as little harm to the tree as possible.

10. The dressing of the wounds of the tree, where a large branch has been amputated, is a work requiring very considerable taste, both in order to preserve the wood from decaying till the wound heals over, and to bring the wound to the same colour as the bark of the tree, and as like it every way as possible.

CHAPTER XII.

CONCLUSION.

Amongst the names of celebrated planters and writers on trees and shrubs may be mentioned the following, and it is very remarkable how many there are of the Christian name *John*. I have noted the following, and doubtless there are many others if only known:—

The oldest and first-mentioned forester in the world was Asaph, who lived 2332 years ago (Nehemiah ii. 8); and it would have been well for the land of Palestine if his posterity had followed the same occupation with greater fidelity, which they unfortunately did not—for it is very evident that the destruction of the royal forests of Lebanon, and the private forests of Hareth (1 Samuel xxii. 5), Ephraim (Joshua xvii. 18), Bethel (2 Kings ii. 24), Carmel (2 Kings xix. 23), the forest or wood of Ephraim (2 Samuel xviii. 6), the forest of Arabia (Isaiah xxi. 13), and all over the Holy Land, was very greatly the cause of its sterility and present barren condition.

Rev. W. M. Thomson, in his 'Land and the Book,' speaking of the Cedars of Lebanon, says: "The platform where the cedars stand is more than 6000 feet

above the Mediterranean, and around it are gathered the very tallest and greyest heads of Lebanon. The forest is not large, not more than 500 trees, great and small, grouped irregularly on the sides of shallow ravines, which mark the birthplace of the Khadîsha or Holy River. I counted 443 trees, great and small, and this cannot be far from the true number. This, however, is not uniform. Some are struck down by lightning, broken by enormous loads of snow, or torn to fragments by tempests. Even the sacrilegious axe is sometimes lifted against them. But on the other hand, young trees are constantly springing up from the roots of old ones,[1] and from seeds of ripe cones. I have seen these infant cedars in thousands just springing from the soil; but as the grove is wholly unprotected, and greatly frequented both by men and animals, they are quickly destroyed. This fact, however, proves that the number might be increased *ad libitum.* Beyond a doubt, the whole of these upper terraces of Lebanon might again be covered with groves of this noble tree, and furnish timber enough not only for Solomon's temple and the house of the forest of Lebanon, but for all the houses along this coast. We have seen larger trees every way, and much taller, on the banks of the Ohio; and the loftiest cedar might take shelter under the lowest branches of California's vegetable glories. Still they are respectable trees: the girth of the largest is more than 41 feet; the height of the highest may be 100. The largest, however, part into two or three, only a few feet from the ground. Their age is very uncertain; nor are they

[1] Mr Thomson is here evidently under a misapprehension as to the cedar growing from suckers or stools, as it is only propagated from seed.

more ready to reveal it than others who have an uneasy consciousness of length of days. Very different estimates have been made. Some of our missionary band, who have experience of such matters, and confidence in the results, have counted the growth (as we Western people call the annual concentric circles) for a few inches into the trunk of the oldest cedar, and from such data carry back its birth 3500 years. It may be so: they are carved full of names and dates, going back several generations, and the growth since the earliest date has been almost nothing."

DUKES.

Of distinguished Duke planters of the name John, may be mentioned His Grace JOHN, DUKE OF ATHOLE, the celebrated and renowned larch-planter, who planted at Blair-Athole and Dunkeld between the years 1774 and 1830 the unprecedented number of 24,756,000 trees (principally larch), on 15,473 imperial acres of ground.

His Grace JOHN, DUKE OF BEDFORD, who planted the far-famed and justly celebrated plantation called the "Evergreens," in commemoration of his daughter's marriage at Woburn Abbey, 1745.

His Grace JOHN, DUKE OF MONTAGU, planted very extensively at Boughton, near Northampton. He was called "John the Planter." It was principally elm and lime trees he planted. Some of the avenues are said to be forty miles in length. He is also reputed to have projected the plan of planting an avenue of trees all the way from Boughton to London, a distance of

about sixty miles, but was prevented doing so for reasons unexplained. He died 1790.

EARLS.

Of famed Earl planters of the name of John, none deservedly stands higher than that of JOHN, seventh EARL OF SEAFIELD, born 1815, and died February 1881. His lordship planted principally on the Strathspey estates, between the years 1853 and 1881, the enormous number of sixty million plants, principally Scots fir, on 45,000 imperial acres of moorland.

EARL CAWDOR, JOHN FREDERICK CAMPBELL, a very extensive and successful planter.

BARONETS.

Of Baronets there are a considerable number of Johns, all less or more distinguished as planters or writers on trees, shrubs, or gardening.

Sir JOHN NASMYTH of Posso, born 1803, who beautified and adorned Dawick, his residence in Peeblesshire, as few gentlemen have ever done. The fruits of his labours may there be seen to-day in the great profusion of rare and costly trees, shrubs, and herbaceous plants of all kinds. There are also to be seen a few of the original larches first planted in the country, together with some splendid acacias, horse-chestnuts, and forest-trees of large size and great profusion.

Sir JOHN SINCLAIR, Bart. of Ulbster, in Caithness, a distinguished patriot and voluminous writer on agri-

cultural subjects; founder of the Board of Agriculture. He was more an experimental and practical agriculturist and planter than a writer, although he wrote very extensively. He wrote an account of the effects of barking fruit-trees to improve the fruit, &c.

OTHER PLANTERS NAMED JOHN.

The Rev. JOHN BROWN, Haddington, who died June 1787, wrote in his 'Dictionary of the Bible' all that could well be said of trees mentioned in sacred writings.

The Rev. JOHN TRUSLER, LL.D., a singular literary character, was born in London in 1725. He was brought up to physic, but contrived to get into holy orders, and officiated as curate. In 1771 he began to publish sermons. He next established a bookselling business upon an extensive scale, acquired a fortune, and purchased an estate at Enfield Green, where he died in 1820. He also wrote 'The Art of Gardening,' and 'The Lady's Gardener's Companion'

JOHN REID wrote the 'Scot's Gardener' for the climate of Scotland, and gave many directions for planting trees, in 1721.

JOHN LINDLEY, the greatest botanist and writer on trees and shrubs in any age. He was editor of the 'Gardeners' Chronicle' for a quarter of a century.

JOHN COCKBURN, Esq. of Ormiston, Haddingtonshire, succeeded his father in the estate in 1714. He was eminent alike in agriculture as in arboriculture. He was the first who constructed hedges and ditches for

field fences, and planted hedgerow trees. He was laird, farmer, and member of Parliament for Haddingtonshire from 1707 to 1741.

John Gould Veitch, of London, went to Japan in 1860, from whence he sent home many rare trees and shrubs, and was the first European to go to the top of the sacred mountain called Fusi Yama, 4000 feet high, in the island of Nippon. He was born April 1839, and died August 1870.

John Mathieson, Esq., Ardross Castle, Ross-shire, planted and beautified his Ardross and other estates in a way and manner, and to such an extent, as few landed proprietors have ever done.

John Evelyn, F.R.S., author of the 'Sylva,' published 1662. He was born at Wotton 1620, and died 1706 in the eighty-sixth year of his age. He wrote extensively on tree-culture, and many other subjects as well. His 'Sylva' is very interesting reading, and though much of his teaching is speculative and fanciful rather than practical, yet no small amount of instruction may be acquired by reading it. He planted the great chestnut-trees in Windsor Park, which are now 240 years old.

John Robinson, Esq., Sion, near London, planted in Great Windsor Park, during fourteen years from 1790 to 1804, 11,225,000 acorns. He was ranger of the park at that time, and his daughter was the present Marquis of Abergavenny's grandmother.

John Claudius Loudon, born 1782, and died 1842, wrote many books on tree-culture, and contri-

buted very greatly in encouraging landed proprietors about London to plant forest-trees. Amongst other books he wrote the 'Cyclopedia of Trees and Shrubs,' 'Hortus Botanica,' &c., &c.

John Sneyd, Esq. of Belmont, Staffordshire, distinguished himself as a tree-planter, and did much to introduce and popularise the larch in his own district about 1788.

John Grigor, nurseryman, Forres, was not only very famous and successful as a nurseryman, but was also an extensive contract planter; and his book on Arboriculture is probably the best on the subject yet written, and which all foresters should read and study. Born at the Haugh, Elgin, 26th March 1806, and died at Forres 14th May 1881. He was several times in Belgium, and also in France and Germany. Mr Grigor was both an enthusiast on trees and a very talented gentleman.

John Hill, M.D., a great writer on trees, shrubs, and other rural subjects. He was born about 1716, and died 22d November 1775. A detailed account of him is given in Loudon's 'Encyclopedia.'

John Gerarde, a London surgeon, had the first botanic garden in England. He wrote on herbs as well as trees and shrubs; was born in Cheshire 1545, and died about 1607.

John Parkinson, a herbalist and botanist in London of great celebrity, was born in 1567, and died about 1640. He was herbalist and botanist to

James I. and Charles I. Professor Martyn says his 'Paradisus' is the first book on gardening worth mentioning.

John Tradescant, a Dutchman who came to England. He travelled as far as Russia, collecting plants in Barbary and the Mediterranean. About 1629 he obtained the title of gardener to Charles I. He founded his garden at Lambeth at a date unknown, made a collection of natural history, and formed a splendid museum, called Tradescant's Ark. In what year he died is unknown, but he was an old man when he published his book.

Dr John Beal, a Hereford gentleman and ingenious divine. He was born in Herefordshire 1603, and died 1683. He is the author of several works, embracing experiments on the running of sap, the connection of certain parts of the tree with those of the fruit, &c.

John Rose, gardener to Charles II. at St James's, wrote a book on the Vineyard and how to make Wine. First printed with Evelyn's 'French Gardener' in 1690.

John Worledge published a book called 'Systemæ Agriculture: the Mystery of Husbandry discovered.' London, 1668.

John Mortimer, author of a book titled, 'The whole Art of Husbandry in the way of Managing and Improving Land.' His works were translated into Swedish, and published in Stockholm 1727.

John Thompson, a commercial gardener at Newcastle-on-Tyne, author of several books on Horticulture, published 1758.

John Abercrombie, author of sixteen different books on Gardening, Shrubs, Trees, &c. He was probably born near Edinburgh in 1726. He went to London, where he lived an active and useful life, and died on 15th April 1806. His book of greatest merit, 'Every Man his own Gardener,' was written by him in prison; but why he was in prison one would like to know.

John Locke, one of the greatest philosophers this country has ever produced. He was born in Somersetshire 1632, and died at his fine seat in Norbury Park, in Surrey, 1704. He wrote extensively on many subjects, amongst others on the 'Rise and Progress of the Taste of planting Pleasure-Grounds, Park-Trees,' &c.

John Coakley Lettsom, M.D., F.R.S., was born on a small island called Little Vandyke, near Tortola, in 1774, and died 1815. He wrote several books, including 'Hortus Uptonensis,' 1781; 'A Rural and Horticultural Sketch,' 1804; 'On the Beta Cicla, or Root of Scarcity;' 'Thoughts on Building and Planting,' &c.

John Greffer, a native of Germany, who came to England about the middle of the eighteenth century; was some time under Mr Millar, gardener to James Vere, Esq. of Kensington; afterwards with Mr Thomson, seedsman, Millend. He afterwards received from

Sir Joseph Banks the appointment of gardener to the King of Naples at Caserta. He was employed by Admiral Nelson to look after his estate at Bronte, and by various noblemen to lay out their grounds. He was killed by falling from his gig, within a mile of his own house, in 1816.

John Giles, gardener, Lewisham, Kent, died in 1797, in his seventy-second year. He wrote several books on Gardening, and is described by Loudon as a clear, practical, and explicit writer.

John Gibson, M.D., a native of Scotland, author of several books on Horticulture and other subjects.

John Dicks, gardener to His Grace the Duke of Kingston. He wrote a Dictionary on the Art of Gardening, containing the most approved methods of cultivating all kinds of trees, plants, and flowers.

John Duncombe, author of some works on Antiquity; but best known as the inventor of the Dendrometer,—'A Treatise on the Dendrometer, a new invented Instrument for the Measurement of standing Trees,' &c.

John Ellis, Esq., a native of Ireland, and distinguished naturalist, who died 1771. He wrote numerous tracts and papers to the Transactions of the Royal Society, including Directions to Voyagers for bringing home Plants; on the Methods of Preserving Seeds; Historical Account of the Coffee Plant, its Culture, &c.

John Winch Nathaniel, F.L.S., an able practical

botanist, and who wrote an essay on the 'Geographical Distribution of Plants throughout the Counties of Northumberland, Cumberland, and Durham,' Newcastle, 8vo.

JOHN COWEL, gardener at Hoxton, writes an account of the Olive in blossom, Torch, Thistle, and Glastonbury Thorn; Newest Methods of improving Land by Grain or Seed; Description of the Great Aloe, &c.

JOHN LAWRENCE, M.A., an eminent naturalist, admitted of Clare Hall, Cambridge, B.A., 1688. He was fond of gardening, and considered it a recreation. He wrote 'The Clergyman's Recreation,' showing it to be pleasant and profitable. He died 1732.

JOHN BONFEIL wrote several books on Vine-Dressing, Drying Fruits, the Art of Making Silk, &c., London, 4to.

JOHN SADLER, F.R.G.S., lecturer and assistant to the Professor of Botany in the University of Edinburgh.

JOHN ANDERSON, nurseryman, Perth, one of the originators and founders of the Royal Scottish Arboricultural Society.

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THE END.

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